MAR 1 - 1933

THE MARCH SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

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The Child and the Tuberculosis Problem. J. ARTHUR MYERS. xii + 230 pp. Illustrated. $3.00. Charles C. Thomas.

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THE SCIENTIFIC MONTHLY

MARCH, 1933

The Scientific Work of the Government of the United States

SCIENCE IN THE DEPARTMENT OF COMMERCE

By Secretary ROY D. CHAPIN

U. S. DEPARTMENT OF COMMERCE

In many ways it is the business of the United States Department of Commerce to bring science and technology to the aid of world-wide commerce by services both regulatory and promotive. The five bureaus which regulate are chiefly of long standing; the promotive functions were largely evolved during the present century. The regulatory functions apply known technical data, while the promotive functions blaze new trails through research.

Commerce and science are closely related. At the dawn of history men used stars as guides on the sea or across the desert. Commerce ramifies to the ends of the earth and to all science and technology to serve and be served. When in untrod lands explorers display novel wares to new peoples for diplomatic barter, commerce begins. It follows close on the heels of the explorer. Those who visited foreign ports became close observers of natural phenomena and thus acquired travel lore and some knowledge of astronomy and meteorology.

Science was called to aid, for trade routes must be safe and sure. We can not entrust rich argosies of commerce to uncharted seas exposed to unknown perils. It is, therefore, natural that certain federal scientific bureaus are found in the Department of Commerce.

The magnetic needle guides navigation, but it is not enough to have a compass. Its deviation from true north must be known, for the needle is not "true to the pole." Its deviations change with place and time. The laws of change must be known. Hence experts of the Coast and Geodetic Survey measure and chart daily, seasonal, long-term and abrupt changes in the deviation of compass north from true north. The Survey, founded in 1807, and the oldest scientific bureau in the government, is the Department's unit for precise survey of our domain and its coastal waters. Its transcontinental arcs, level network and tidal datum planes, unexcelled for precision, give the national basis for location of places and routes of commerce. Charts of waterways show depths, shallows, reefs and submerged wrecks, giving navigation safe channels. Some 700 charts are maintained and published by the Survey. Of these, 286,000 were sold in a single year. Ninety-two airways maps cover the entire country, and strip maps are printed in convenient form for air pilots.

The tides are factors in commerce.

—Underwood and Underwood, Washington, D. C.

ROY D. CHAPIN

SECRETARY OF THE DEPARTMENT OF COMMERCE.

The Survey gathers data from automatic tide records, adds astronomical and meteorological rhythms and computes tides for the leading ports of the world. Its tide-predicting machine—a masterful invention of departmental experts—computes automatically what would otherwise require forty trained computers. The resulting tide tables have a world-wide circulation, aiding commerce, which must observe time and tide, which wait for no man.

The Survey's earthquake records aid the selection of sites for construction, and its data on refined geodetic surveys enable its experts to compute the shape of the earth, its dimensions and changing levels by which "isostasy" adjusts the crustal masses of the earth to equate their pressure distribution. Thus the earth, the stage of the drama of commerce, is the basic interest of a great unit of the Department.

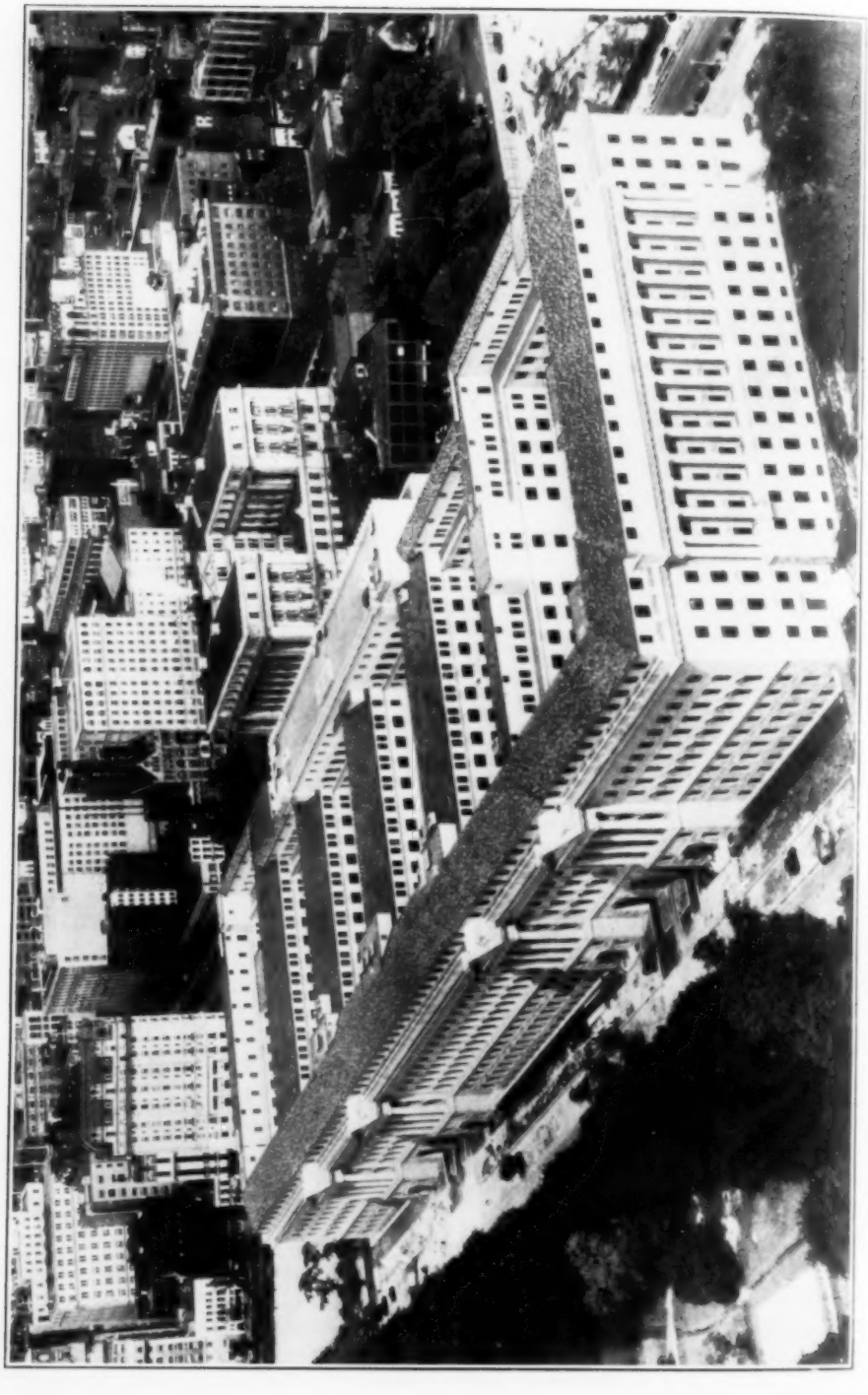
Closely linked with some of the activities of the Coast and Geodetic Survey, and, in fact, growing out of them, is the work of another scientific unit of the Department—the Bureau of Standards.

Uniform standards are absolute essentials of commerce. Without standards of measurement, quality, performance and practise, hopeless confusion would result and trade would come to a standstill. Less than 30 years after the establishment of the Coast Survey, its office of standard weights and measures was distributing uniform standards of length, mass and capacity to the federal custom houses and to the state governments to the end that commerce with foreign nations and within the United States might be on a uniform basis. By act of Congress in 1901 the functions of this office were enlarged and its name changed to the Bureau of Standards. It was authorized to assist the government, industry and individuals in all matters pertaining to standardization. It is the custodian of our national standards of length and mass, and, using these as a basis, constructs multiples and subdivisions, and derives standards for every kind of measurement. It develops standards in new fields, such as radio and x-rays, and improves existing standards to keep pace with industrial developments. It sets up standards of quality for many of the articles of commerce and establishes standards of performance for many of the machines by which commerce is carried on, as the internal combustion engine; and draws up standards of practise to safeguard workers from the hazards which commerce brings in its train, as in the generation, distribution and utilization of electrical energy.

In its development and improvement of standards, the Bureau cooperates with almost every industry. Its investigations lead to better and cheaper products and improved service with conservation of lives and natural resources. It aids directly the manufacturer, distributor and consumer by pointing the way to possible reductions in the sizes and varieties of articles in common use, and by promoting uniform standards of quality.

The Bureau acts as the principal research and testing laboratory of the federal government, and has helped to place governmental purchasing on a scientific basis. It assists in the preparation of specifications which simplify the commercial transactions between the government and industry. It is, likewise, a clearing house for all matters of standardization affecting the United States and other nations, and in this way is helping to place the standards essential to world commerce on a basis of international uniformity.

It is obvious, then, that over land, sea and air commerce is entering a new era in which science looms large. Profiles of aircraft are streamlined in laboratory wind tunnels. Unanticipated speeds span our continent in less than half a day. Radio waves keep aircraft "on



BUILDINGS OF THE DEPARTMENT OF COMMERCE

course" in continual touch with base, so that dead-reckoning hazards vanish.

Scores of aids to navigation are maintained by the departmental units to perfect transport by land, sea and air. What is true of navigation is true of other factors affecting commerce. Weights and measures ensure equity in trade. The yields of mines and fisheries are increased and improved, as commerce, through research on extraction and production, improves products and processes. It is to-day fair to say that success in commercial enterprise rests on the intelligent use of data placed in the hands of the business man by the scientific man.

Commerce is promoted most directly by a special unit of the Department—the Bureau of Foreign and Domestic Commerce. Its economists and technicians on the firing line of business crusading are alert in forecasting trade conditions and opportunities. Statistics from a world-wide front reveal latent factors in success which have helped to make our country a leader in foreign trade. This unit promotes domestic trade as well. The exigencies vary with time and place and must be taken into account. This calls for studies in the psychology of peoples, their social controls, customs and specific needs.

The laws of trade may yet be formulated in a new technology in which standards and measurements of quality, quantity, value, place and time—the five coordinates of commerce—may be effectively correlated. This may even flatten the curve of the business cycle, making prosperity continuous rather than occasional. Until then the program of the Department is to give all business men dependable knowledge of the best business experience and judgment of our time.

On land, obstacles are easily seen. On the water, hazards may be hidden. To maintain aids to safe and sure navigation of water or air is the function of the department's unit, the Bureau of Lighthouses. On a homebound ship we determine position by radio beacon signals from numerous stations along our shores. Next we may pick up a lightship, a floating lighthouse moored perhaps twenty miles off shore. Next appears one of the great first-order lights with its million-candlepower beam to mark outer promontories or obstructions of the coast. Then appear the smaller second-order or third-order lights within the bay, and, lastly, buoys marking the channel to safe harbor. The aids to navigation provided by this Bureau call for ingenuity and technical knowledge both in the design and in the maintenance of uninterrupted service. An important recent aid maintained by the Bureau of Lighthouses is the airways beacon, visual and radio. These indicate to an air pilot whether he is on or off course in dark or fog, and if off course how he must fly to get back on course again. This unit in many ways renders a fundamental service to commerce, promoting speed, safety and precision in navigation.

The safety of all who "go down to the sea in ships" is the concern of the Department's navigation and steamboat inspection unit. Water-borne commerce on steam vessels includes three hundred million passengers a year. Their safety is assured by trained inspectors, who quietly and unobtrusively safeguard life and property from the perils of defective equipment and operation—perils as real as those of the sea. Science and technology are involved.

With every precaution private owners can take, accidents do occur. Hence systematic regulation and inspection are imperative. A boiler explosion or a fire is far more serious at sea than on land. Hence boilers, fire-detecting, fire-fighting, life-saving and steering apparatus are regularly inspected. With government supervision accidents are far less frequent. Boiler material is tested at

the mills, boilers are examined under construction, and tested when completed, their safe working pressures being computed. Inspection of vessels begins when the keel is laid and continues during construction.

Simple rules of safety apply even to small motor boats, of which several hundred thousand ply on navigable waters and must register with the Department of Commerce under the law. These rules are enforced by the Bureau of Navigation and Steamboat Inspection. Vessels of our merchant marine are inspected annually and certified for a year if found seaworthy. Excursion and ferry steamers are inspected more often. In these and other ways this important unit affecting safety on our waterways is actively reducing accidents by removing the hazards which cause them. In modern times safety is a problem of technology which finds its basis in the science of materials, devices and processes.

Air commerce is modern. When commerce took to the air new problems arose —some administrative, some highly technical and calling for experimental research. The Aeronautics Branch of the Department is charged with the subject of commercial aeronautics. Airplanes and pilots are examined. If the aircraft act is violated, a fine or revocation of license follows. For the Aeronautics Branch, aircraft motors are tested by experts of the Bureau of Standards. If found airworthy they are accorded the Department's airworthiness certificate. Mapping the airways is the work of the Coast and Geodetic Survey; aids to air navigation are provided by the Lighthouse Service; research is assigned to the Bureau of Standards; and cooperating committees report on outstanding problems.

Recent achievements are the system of plane-to-ground telephony and the systems of multiple radio ranges designed to serve as airways in fog or darkness. A truly sensational possibility is the system of blind landing devised by Bureau of Standards experts in cooperation with the Aeronautics Branch. This points to navigation of the air by automatic control. Much research and field work remains to be done, but the trail is blazed toward perfected built-in controls which may yet eliminate the hazard of human pilotage.

The fisheries industry has been notably aided by the Department's Bureau of Fisheries. The arts of quick freezing, efficient packaging and the recognition of the food values of sea food in combating faulty nutrition are making fishery products more popular with the consuming public. The industry, however, suffers from certain natural handicaps, such as the distance of the sources of supply from centers of population, the seasonal nature of the catch and the uncertainty of its volume, so that research must be continued if fishing is to maintain its important industrial position.

The Bureau conserves the supply of food fishes by taking measures to prevent pollution of lakes, rivers, small streams and coastal waters by manufacturing or populous centers. It also aims to keep sources well stocked with fish. On the initiative of the Department, Congress authorized research on fish diseases, a subject vital to public health and to our edible fish supply.

International cooperation is essential to conservation. The Department is concerned with the project of the League of Nations to conserve those species of whale which are still sufficiently numerous to form an important industry. Certain species almost wiped out will become extinct unless the industry is regulated. A well-known project protects the fur seal in the North Pacific. The nations concerned have saved the fur-seal herd which breeds on the Pribilof Islands in Bering Sea. Once threatened with extinction, the herd is now a gain-

ful flourishing economic resource. Under 21 years of the international treaty the herd has steadily grown until now 50,000 surplus 3-year old male seals are taken annually. Similar protection is afforded foxes on the St. Paul and St. George Islands, and sea otters, sea lions and walruses.

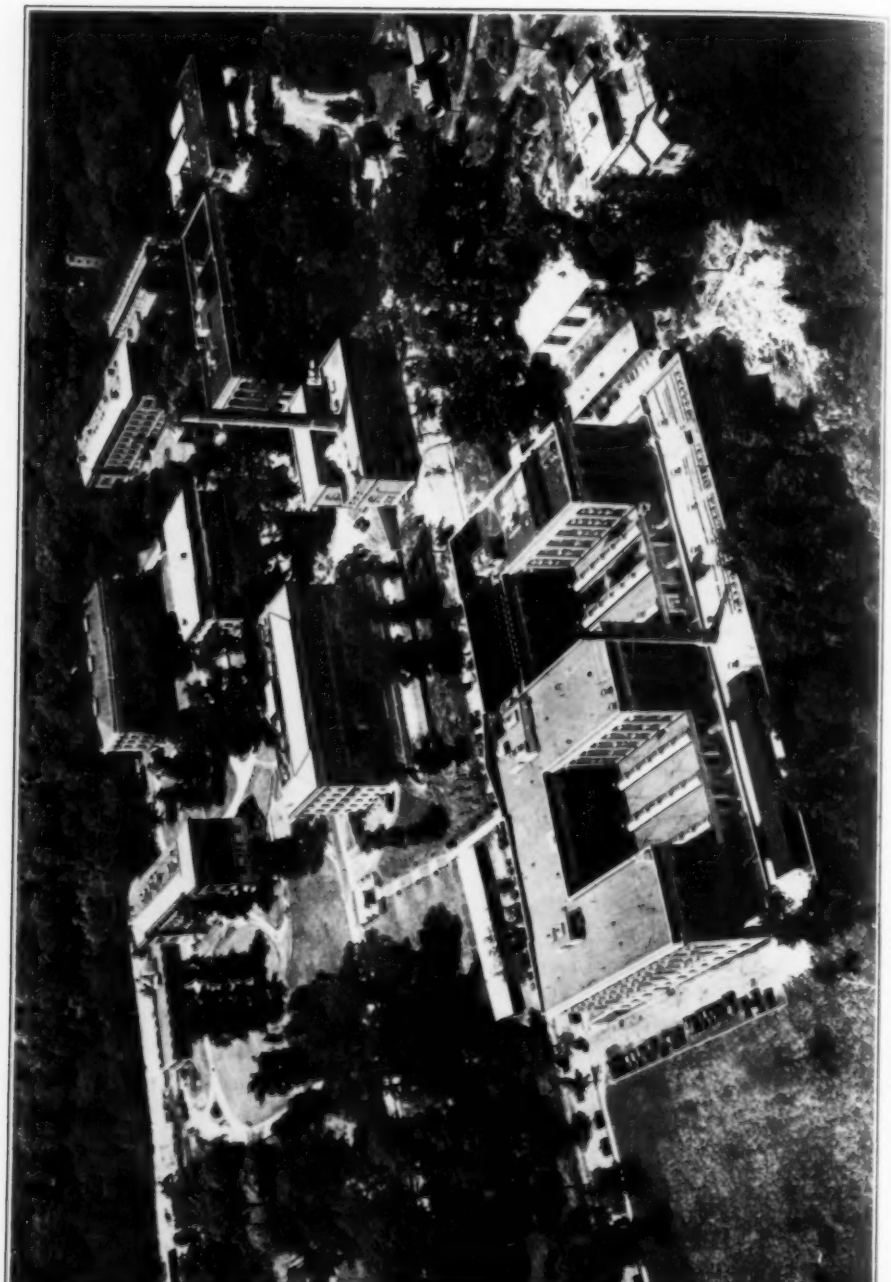
Technical studies yield valuable data for the fishing industry. The life habits of fish and the changes in the abundance of various kinds of fish are studied. An efficient fish ladder for the upstream migrations of the salmon and other fish was developed in cooperation with the states and the industry. The Bureau's aid to the pearl button and goldfish industries will long be remembered.

Mine products bulk large in commerce. The Department's unit dedicated to this great industry, the Bureau of Mines, conserves mineral wealth, reduces waste in the mineral industries and helps to make these industries safe and healthy for miners. Its administrative, technologic, economic, safety and health services are widely known and appreciated. Its scientific research on helium brought this once rare gas from the laboratory into commerce, with an annual production of 24,000,000 cubic feet for use in giant airships. New methods devised by the Bureau save millions in metal losses. Its technical studies cover such varied subjects as electric smelting, lead and zinc wastes, the physics and chemistry of steel making, the flotation of zinc, the recovery of lead and copper by leaching from oxidized ores, and the recovery of precious metals.

The Bureau of Mines has an experimental blast furnace (the only one of its kind) for the detailed study of temperature distribution, furnace gas composition and the moving charge. It has shown how to reduce operating costs. The Bureau is a potent factor in advancing the mining industry and its bulletins are appreciated sources of dependable data for commercial enterprise in the mining field.

Our national life—its activities and possessions—is gaged by the census unit of the Department of Commerce. Great volumes result, data which guide alike business and statecraft in meeting changing conditions in industry and commerce. Since 1790 the Census has steadily developed in scope of subject, area of domain covered, in its precise formulation of results and in the efficient means for computing their sums and relations. These statistical harvests provide for commerce a measure of sources and markets. Starting with its house-to-house mission reaching every home, the Bureau of the Census resorts finally to automatic high-speed machines which classify and integrate the vast volumes of data as a basis for the sociologist, the economist and the historian in their scientific researches on our national life.

Inventions multiply the articles of commerce and the mechanisms which it uses. They profoundly affect human life—aid its well-being, add comforts and luxuries once undreamed of. To stimulate invention Congress set up the Patent Office, to assure inventors property rights for a period. Technicians study the inventor's claims and allow only those that are novel so that the monopoly allowed is equitable. Science enters the work of this unit, for the inventor's claims often involve highly technical problems in physics and chemistry. Patent files are a notable source of technical history, and its claim correspondence is rich in technical discussion of the state of the arts. Fifty thousand new inventions a year have an effect on our civilization which can not be visualized, ramifying to the minutest details of our industrial régime.



AIRPLANE VIEW OF THE BUILDINGS OF THE BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

By the Late Dr. GEORGE K. BURGESS[1]

DIRECTOR OF THE NATIONAL BUREAU OF STANDARDS, 1923–1932

MEASUREMENTS to-day play a leading rôle in human progress, and their range, precision, variety and uses multiply incredibly. Experts themselves hardly realize how fully this ancient art of measurement has become the peerless tool of discovery, record and control in science and industry. Measurement is recreating industry through enhanced accuracy at all points and more facile measuring methods which tend to become automatic. The procedure which measures a thing may be turned back to control its magnitude. Energy equivalent to that of a fly may regulate thousands of horsepower. Furnace heat is measurable and if we have a unit, a standard, a method and a measuring device we may also control that furnace heat. The sum of such automatic controls assures the quality of a product or its accuracy. Effective measurements set up by research replace empirical judgments and become standards of practice to control industrial processes.

Standard weights and measures are as old as civilization. Standards are true autocrats, with a domain as broad as human activity. They ensure justice and accuracy, matters so important that to maintain the standards is a basic function of the central government. The Great Charter mentions them and our Federal Constitution gave Congress power to "fix the Standard of Weights and Measures."

Standards must be applied to be of service to man. They are not mere inert relics deposited in a vault but are actively functioning as process controls of industry, affecting every detail of manufacturing operations and products. Measurements embodied in standards of size, quality or performance thus become supervisory of the complex of motions and conditions which we call industry. By research we may determine experimentally the best magnitudes—safe minima, attainable maxima, economic optima. What mixture of air and gas gives most car miles? The answer becomes a standard for engine designers in promoting progress for tank, boat, car, airship and airplane. A thousand industries need such basic data upon which to build progress. This is one purpose of our National Bureau of Standards.

The Bureau was founded as a research laboratory to develop, construct and maintain the reference and working standards, and to intercompare, improve and apply them in every field in which they are used. Its activities in research and standardization make a narrative of impressive interest in pure and applied science. The Bureau, besides furnishing the standard basis of measurements for the countless transactions of daily trade, also conducts hundreds of researches of vital concern to science, industry and commerce. It encourages industry to eliminate needless varieties and sizes of products and to standardize their quality by national specifications. In the interest of pure and applied science, its work ranges from measuring the heat of a star to things as practical as paving brick, as subtle as the earth's magnetic field or infinitesimal as the force in a single atom. The same instrument which measured the surface tem-

[1] This posthumous article was the last written by Dr. Burgess. On July 2, 1932, he was stricken at his post and died without regaining consciousness. It is most fitting that his last writing should be an introduction to a series of articles on the institution to which he had devoted the best years of his life with such outstanding success.

SAMUEL WESLEY STRATTON

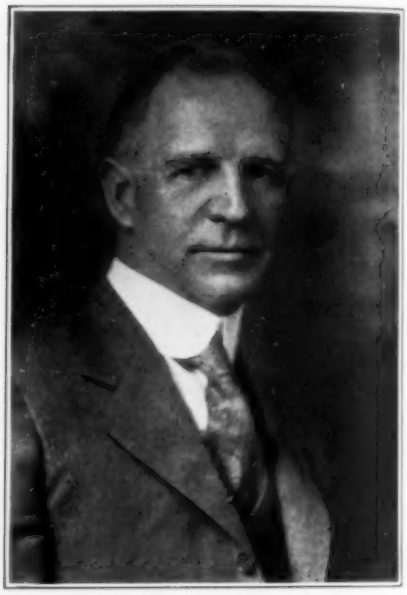
THE FIRST DIRECTOR OF THE NATIONAL BUREAU OF STANDARDS, WHO SERVED FROM 1901 TO 1923 WHEN HE BECAME PRESIDENT OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY. HE DIED IN 1931.

GEORGE KIMBALL BURGESS

DIRECTOR OF THE NATIONAL BUREAU OF STANDARDS FROM 1923 UNTIL HIS DEATH LAST SUMMER.

perature of Mars is now being used to study combustion in an engine cylinder.

The strength of the Bureau's work is in its joint attack on complex problems from many salients in scores of specialties by experts picked by merit, trained intensively in narrow fields, working in contact with the seventy specialized fields of Bureau work. Such training has developed many leaders who have left the Bureau to direct industrial research laboratories and testing stations or remained to head various divisions and sections, since lines of advancement are

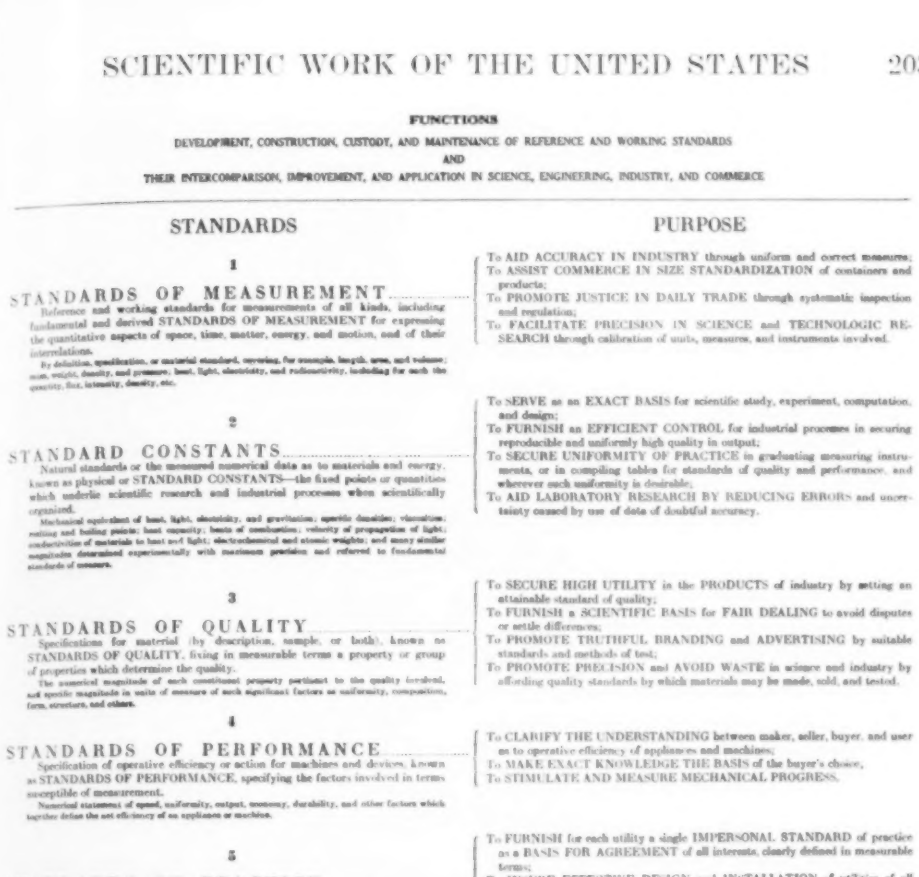


LYMAN J. BRIGGS

ACTING DIRECTOR OF THE NATIONAL BUREAU OF STANDARDS AND CHIEF OF THE DIVISION OF MECHANICS AND SOUND.

open to the highest positions in the Bureau. The section is the unit of specialization, 70 in all, each headed by an expert uniquely equipped with staff, facilities, quarters, literature and a tradition for effective work. Each section must acquire also the techniques, contacts and specialized knowledge so essential to its work.

The leading founders of our government appreciated the importance of ex-


FUNCTIONS
DEVELOPMENT, CONSTRUCTION, CUSTODY, AND MAINTENANCE OF REFERENCE AND WORKING STANDARDS
AND
THEIR INTERCOMPARISON, IMPROVEMENT, AND APPLICATION IN SCIENCE, ENGINEERING, INDUSTRY, AND COMMERCE
STANDARDS
PURPOSE
1
STANDARDS OF MEASUREMENT
Reference and working standards for measurements of all kinds, including fundamental and derived STANDARDS OF MEASUREMENT for expressing the quantitative aspects of space, time, matter, energy, and motion, and of their interrelations.
By definition, specification, or material standard, covering, for example, length, area, and volume; mass, weight, density, and pressure; heat, light, electricity, and radioactivity, including for each the quantity, flux, intensity, density, etc.
To AID ACCURACY IN INDUSTRY through uniform and correct measures;
To ASSIST COMMERCE IN SIZE STANDARDIZATION of containers and products;
To PROMOTE JUSTICE IN DAILY TRADE through systematic inspection and regulation;
To FACILITATE PRECISION IN SCIENCE and TECHNOLOGIC RESEARCH through calibration of units, measures, and instruments involved.
2
STANDARD CONSTANTS
Natural standards or the measured numerical data as to materials and energy, known as physical or STANDARD CONSTANTS—the fixed points or quantities which underlie scientific research and industrial processes when scientifically organized.
Mechanical equivalent of heat, light, electricity, and gravitation; specific densities; viscosities; melting and boiling points; heat capacity; heats of combustion; velocity of propagation of light; conductivities of materials to heat and light; electrochemical and atomic weights; and many similar magnitudes determined experimentally with maximum precision and referred to fundamental standards of measure.
To SERVE as an EXACT BASIS for scientific study, experiment, computation, and design;
To FURNISH an EFFICIENT CONTROL for industrial processes in securing reproducible and uniformly high quality in output;
To SECURE UNIFORMITY OF PRACTICE in graduating measuring instruments, or in compiling tables for standards of quality and performance, and wherever such uniformity is desirable;
To AID LABORATORY RESEARCH BY REDUCING ERRORS and uncertainty caused by use of data of doubtful accuracy.
3
STANDARDS OF QUALITY
Specifications for material (by description, sample, or both), known as STANDARDS OF QUALITY, fixing in measurable terms a property or group of properties which determine the quality.
The numerical magnitude of each constituent property pertinent to the quality involved, and specific magnitude in units of measure of such significant factors as uniformity, composition, form, structure, and others.
To SECURE HIGH UTILITY in the PRODUCTS of industry by setting an attainable standard of quality;
To FURNISH a SCIENTIFIC BASIS for FAIR DEALING to avoid disputes or settle differences;
To PROMOTE TRUTHFUL BRANDING and ADVERTISING by suitable standards and methods of test;
To PROMOTE PRECISION and AVOID WASTE in science and industry by affording quality standards by which materials may be made, sold, and tested.
4
STANDARDS OF PERFORMANCE
Specification of operative efficiency or action for machines and devices, known as STANDARDS OF PERFORMANCE, specifying the factors involved in terms susceptible of measurement.
Numerical statement of speed, uniformity, output, economy, durability, and other factors which together define the net efficiency of an appliance or machine.
To CLARIFY THE UNDERSTANDING between maker, seller, buyer, and user as to operative efficiency of appliances and machines;
To MAKE EXACT KNOWLEDGE THE BASIS of the buyer's choice;
To STIMULATE AND MEASURE MECHANICAL PROGRESS.
5
STANDARDS OF PRACTICE
Codes and regulations impartially analyzed and formulated after study and experiment into STANDARDS OF PRACTICE for technical regulation of construction, installation, and operation, and based upon standards of measurement, quality, and performance.
Collation of standard data, numerical magnitudes, and ranges of the pertinent factors defining quality, safety, economy, convenience, and efficiency.
To FURNISH for each utility a single IMPERSONAL STANDARD of practice as a BASIS FOR AGREEMENT of all interests, clearly defined in measurable terms;
To INSURE EFFECTIVE DESIGN and INSTALLATION of utilities of all kinds;
To PROMOTE SAFETY, EFFICIENCY, and CONVENIENCE in the MAINTENANCE and OPERATION of such utilities;
To SECURE UNIFORMITY OF PRACTICE where such is practicable, and EFFECTIVE ALTERNATES in other cases.

THE FUNCTIONS OF THE BUREAU OF STANDARDS

act and uniform standards, yet action was slow. Washington held it an obligation that standards be provided. Jefferson, a student of the subject, when Secretary of the Treasury recommended (1790) that standards be adopted. President Madison (1817) reminded Congress of its failure to establish standards. Finally, John Quincy Adams, Secretary of State, after four years of research, made (1821) a brilliant report on weights and measures, which is still a classic. In it he proposed an international conference to establish a universal and uniform system.

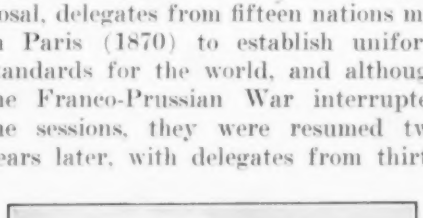
Although, at the early period we are considering, some confusion in commercial transactions might be overlooked, uncertainty in regard to the coinage could not be tolerated. Congress (1828) directed that a brass troy pound weight, secured by our minister in London in 1827, should henceforth be used as the standard for coinage. This troy pound was deposited at the Mint in Philadelphia and besides regulating the coinage it virtually became the fundamental standard of the United States, from which the avoirdupois pound was derived. It remained as our standard for coinage until Congress directed (1911) that the "standard troy pound of the Bureau of Standards" should be used for this purpose.

The Secretary of the Treasury was directed by Congress (1830) to verify the

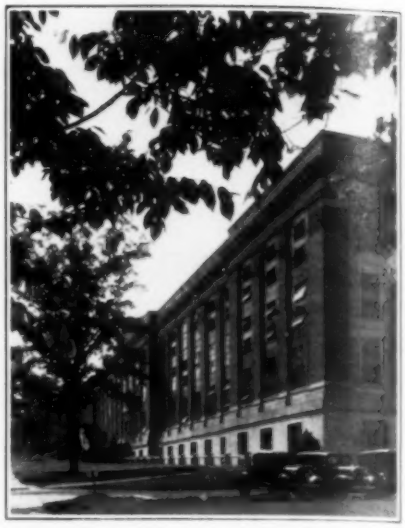
weights and measures of the customs houses, and serious discrepancies were found. As the Constitution requires that "all duties, imposts, and excises shall be uniform throughout the United States," Congress directed the Treasury (1836) to adopt and construct uniform standards and send accurate duplicates to each custom house and to each state government.

Meantime the Treasury began a survey of our coast, having secured a leading metrologist of his day—F. R. Hassles, a Swiss,—to head the work. He brought with him English standards and made up sets based on these, thus fixing our "customary system of weights and measures." A set of the new standards was sent to each custom-house and to each state government. Curiously, nothing was said as to their use, and pertinent federal legislation is still lacking. The standards did, however, aid in securing fair uniformity among the states.

The metric system was made legal throughout the United States for all purposes by Act of Congress (1866), and sets of the metric standards were sent to the States by the Treasury Department. Fifty years after Adams' proposal, delegates from fifteen nations met in Paris (1870) to establish uniform standards for the world, and although the Franco-Prussian War interrupted the sessions, they were resumed two years later, with delegates from thirty



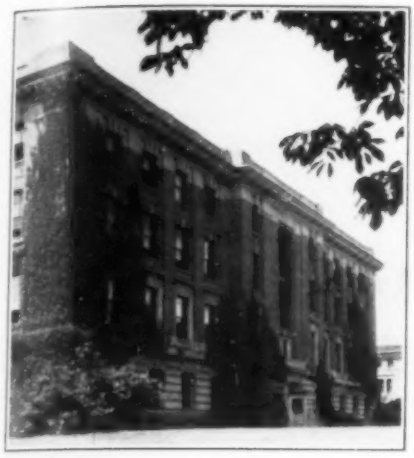
CHEMISTRY BUILDING



INDUSTRIAL LABORATORY

nations in attendance. The resulting treaty (1875) established three new agencies: (1) The International Conference on Weights and Measures; (2) The International Committee on Weights and Measures; (3) The International Bureau of Weights and Measures located on neutral territory near Paris. Together they form a world tribunal of highest resort in matters of weights and measures.

The first treaty obligation (1875) was to construct new standards of the meter and kilogram, that is, standards of length and mass. Sixteen commissions planned the technical details and fourteen years later (1889), the task completed, accurate duplicates (national prototypes) were deposited with each supporting nation (now 32 in all). President Harrison (1890) witnessed the breaking of the seals of the American prototypes now preserved in the Standards Vault of the National Bureau of Standards. These constituted a great achievement, meeting the most exacting demands of metrology. An order (1893) issued by the Superintendent of Weights and Measures, approved by Secretary of the Treasury



SOUTH LABORATORY

Carlisle, therefore made the new metric prototypes fundamental for all units of length and mass and their derivatives, the yard and pound being derived from the meter and kilogram by relations fixed by the act of Congress in 1866.

Thus were adopted our present national standards of length and mass. Such basic standardization was almost the only work of the old Office of Standard Weights and Measures and in its activities derived and working standards, such as are now essentials of industry, had little place. Some other nations were far in advance of us in this respect.

Germany (1868) organized its Normal Aichungs Kommission to regulate weights and measures and (1887) founded the Physikalisch-Technische Reichsanstalt—a national physical laboratory for research and standardization. Great Britain (1879) set up a Standards Department in its Board of Trade to construct and verify copies of standard weights and measures, an Electrical Standardizing Laboratory (1890) and a National Physical Laboratory (1899). Other nations, inspired by the pioneer laboratory (The International Bureau of Weights and Measures) have since established similar institutions.

About 1900 the demand for exact standards in this country became insistent. The value of accuracy was recognized, science contributing much to make such accuracy possible in industry. An age of precision had set in, and leading men of science and industry urged Congress to establish a National Bureau of Standards. On behalf of the International Electrical Conference at Philadelphia (1884) Snyder and Rowland urged through the State Department that a Bureau of Physical Standards be established in Washington. A decade later A. G. Webster urged similar action. After extended hearings (1900) a bill passed by Congress was approved by President McKinley (1901) which begins: "The Office of Standard Weights and Measures shall hereafter be known as the National Bureau of Standards." Its scope was broadened consistently with the modern conception of standards and of the need for research and testing in applying them. Samuel Wesley Stratton, federal inspector of weights and measures in Washington, became its first director. During his administration of twenty-two years, the Bureau became a great institution famous throughout the world and notable for achievements in science and technology.

A beautiful site of 56 acres in the suburbs of Washington about three and a

NORTHWEST LABORATORY

half miles northwest of the White House is now occupied by its nine major and twelve minor buildings—a veritable city of science set on a hill. Originally suburban, it is now the center of a populous urban apartment district and the Bureau has moved certain types of work into neighboring states, notably an aviation engine testing station at Arlington, Virginia, and the radio research stations at Beltsville (17 acres) and Meadows (200 acres), Maryland. Other field stations provide for radio aids to aviation at College Park, Maryland; electric lamp inspection in the New York and Boston district; utilization of farm wastes at Ames, Iowa, and at Auburn and Tuscaloosa, Alabama; testing cement and concrete at Northampton, Pennsylvania, and Denver, Colorado; and testing cement, concrete and miscellaneous materials at San Francisco, California; and ceramics research at Columbus, Ohio. The latest of the Washington group is the National Hydraulic Laboratory, just completed and now being equipped, with a capacity to pump a volume of water per second equal to the water requirements of Washington, and in which fundamenal problems of hydraulic power, flood control and irrigation will be solved experimentally. The Bureau group is well designed for its purpose and presents an impressive appearance—a resort of growing interest to tourists, a favorite target for airplane cameras, and a mecca for scientific and industrial experts meeting in Washington.

PLUMBING RESEARCH TOWER

POWER HOUSE

Under the research associate plan, evolved to perfect and extend the Bureau's cooperation with industry, an industrial group may maintain qualified workers at the Bureau of Standards for research under Bureau supervision on problems of mutual interest. The results are not patented but are for the free use of all industry. As many as a hundred associates from 45 organizations have been at work at the Bureau. The plan permits wise choice of crucial problems for joint attack by the Bureau and the industry, permits fuller use of the Bureau's unique equipment and staff, and assures more prompt application of research results by the industry.

Standards are classified by the Bureau in five groups: Measurement, Constants, Quality, Performance and Practice. The first two are the foundations. The functional diagram shows these classes of

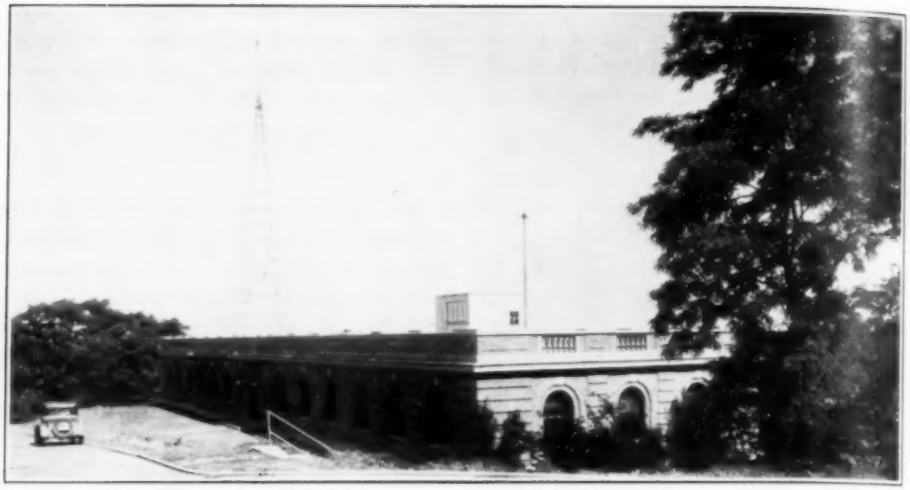
standards, defines them, illustrates them and indicates the purpose and service of each. Their scope broadly covers the measured controls and results of experiment and design—in brief, the quantitative aspects of science and industry. All five functional classes of standards may be involved in each of the scientific and technical specialties represented by the 70 sections of the Bureau's work. The length section has, for example, a basic standard of measurement (length), the meter; a basic constant (temperature), the ice point (0° C.) at which the standard is correct; a quality standard of finish and composition which assures the quality; a standard of performance for each length-measuring device tested; and a standard of practice to be followed by inspectors of trade length-measuring devices.

In theory every product of industry may have a similar group of pertinent standards. A gage block, for example, must have true size (standard measurement), a working temperature (20° C.) at which it is true size, a quality standard for the steel, its annealing and finishing, and a practice standard as to method of use for best results.

Let us consider further these five classes of standards: Measurement, Constants, Quality, Performance and Practice. In measuring light we meet the first group. Carbon filament lamps first used by the Bureau to maintain the unit of light, the candle, are standards. A new international standard of light, now proposed by the Bureau and built and operated with success, is an enclosure radiating at the freezing point of platinum (1773° C.). The radiated light is of definite quality and quantity and the unit candle-power can readily be derived from it with due accuracy. Standards of measurement are not fixed. They may be in any stage of development. The standard kilogram may be in almost a final form, but the standard of length now under investigation may eventually be defined as a certain number of wavelengths of light rather than by a metal bar. "The solution of problems which arise in connection with standards" is a legal function of the Bureau which gives research a scope broad as measurement itself.

The numerical constants of nature are the second class of standards—boiling-points, atomic weights and a thousand similar magnitudes, established as a function of the Bureau by Congress. Under this authority the Bureau determined the atomic weights of hydrogen and oxygen (two fundamentals in chemistry), the constant of gravitation, the velocity of electromagnetic radiation (electrically determined as the ratio of the electromagnetic to the electrostatic unit). The speed of radio and light are credibly believed to be equal so that this constant is of both practical and theoretical interest. The Bureau's determination of the density of pure alcohol closely confirmed the classic determination by Mendeleef fifty years before and may remain standard for fifty years to come. The constants of refrigeration materials measured with high accuracy laid the basis for the era of refrigeration and controlled air conditions indoors. More recently the constants of steam and water were determined to give a similar basis for the new era of high pressure steam power.

Standards of quality are the third class of standards. They are specifications in measured terms which assure intended service with planned effectiveness. Reduction to measurement enables the factory to produce, the dealer to sell, the user to buy on an accurate standard basis of measured size, service, and efficiency. To-day these are indispensable to the interlocking factors characteristic of well-ordered industry. They become the maker's obligation, the dealer's promise and the buyer's understanding. The measured need and the measured product must match each



RADIO RESEARCH LABORATORY

other. The specification or the standard of size or quality is the modern means of assuring such matched measures. The Bureau's work in this field is notable. It promotes voluntary action by industry adopting specifications for products, and it publishes those approved as "Commercial Standards." At this writing 41 projects have been completed, and 33 are actively pending. Approval means that two thirds of the industry have given written approval. Some have as high as 90 per cent. approval, and a recent standard for woolen blankets has 100 per cent. approval. Besides this line of attack, some twenty-seven Bureau experts are chairmen of technical committees which have formulated 774 federal specifications for adoption by the Federal Specifications Board. The Bureau's new National Directory of Commodity Specifications refers to some 25,000 nationally recognized specifications of all kinds, enabling purchasing agencies, public and private, to avail themselves of these up-to-date sources of technical data required in intelligent buying.

Standards of performance specify the factors involved in the effective operation or action of machines and devices in terms susceptible of measurement. The Bureau has by joint research and action aided in formulating such standards of performance as those for fabric measuring devices, gasoline pumps and other liquid delivery pumps, and track scales. For example, by setting limits to permissible errors and tolerances, we in effect, set up a standard of accuracy. The manual for inspectors sets forth specific examples of such standards and the schedule of tolerances aids inspectors and helps to assure reasonable compliance with reasonable standards of performance. A working standard of performance may be illustrated by the test runs of aviation engines made at the Bureau for airworthiness certification by the Aeronautics Branch of the Department of Commerce.

Standards of practice, specifically codes of service and safety, are drafted by or under the auspices of the Bureau. Examples are the handbooks of weights and measures testing practice, codes of safety for the logging industry, for aeronautics, electric service, eye-hazardous industries, and others. The Bureau contributes to the fundamental science in such cases as illustrated by its research on the physics of plumbing system-

which involved experiments in a unique tower laboratory simulating conditions in a modern office building. The data were embodied in the code of minimum requirements for plumbing compiled by the Department of Commerce Building Code Committee and published by the Bureau of Standards.

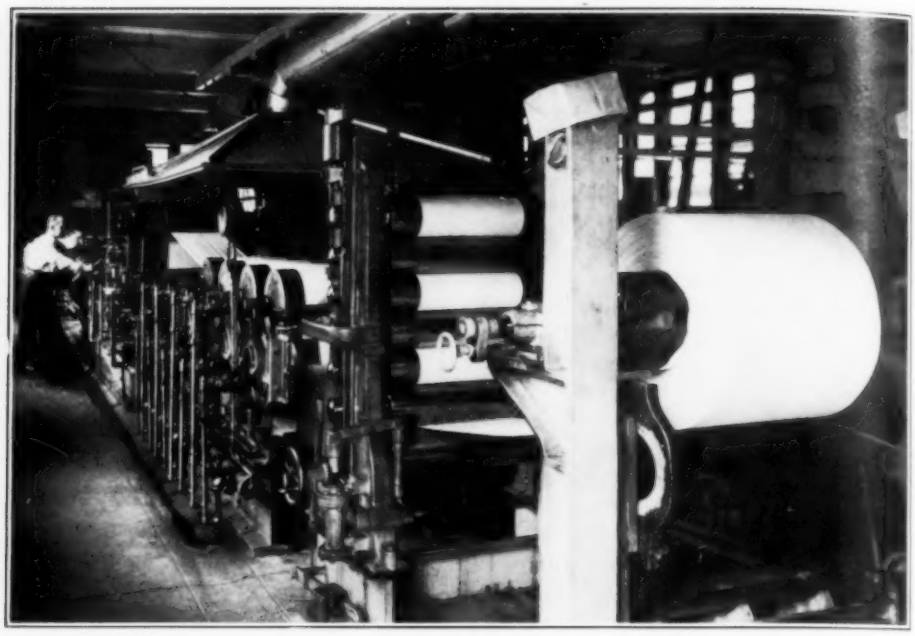
Closely related to constants is the determination of the properties of materials, another function given to the Bureau by Congress (1901). Unusual facilities are available—experimental manufacturing plants in which materials can be made or modified under measured control with every facility for observation and record; induction furnaces for melting metals, a rolling mill, a plant for producing the lowest attainable temperatures, testing machines with capacities up to 10,000,000 pounds, and similar facilities in great variety. Its textile research staff has a modern laundry, devices developed at the Bureau to measure the wear of clothing, carpet or other fabric; ultra-violet light sources to measure the fastness of dyes; a complete mill to spin or weave any cotton yarn or fabric; a weather-controlled laboratory to keep the humidity and temperature constant and standard.

Special devices for the leather work include an experimental tannery, a sole-leather walking wear-machine, and means for measuring the resistance and strength of various tannages. A paper mill and laboratory are equipped to produce any paper of any fiber under measured control and thus permit improvements in the properties of paper. Long life, for example, is a valuable characteristic for paper used as a vehicle for records of history, literature, science and industry. The Bureau found by systematic variation and trial that the sulfur dioxide in the air was the greatest enemy of permanence, almost regardless of the fiber composition. From 15 to 190 tons of sulfuric acid are deposited every year on each square mile of our large cities. This causes a deterioration of cellulose by acid action. Control of the acidity in making the paper within a standard acid content has been found effective in assuring long life to the paper, provided it is properly stored and protected from acid atmosphere or direct sunlight.

A rubber mill, compounding room, vulcanizing ovens and a climate-controlled laboratory permit fundamental experiments in measuring and modifying the properties of rubber. Dynamometer tests here revealed power loss in tires through poor design, much of it preventable. The Bureau has by distillation obtained a transparent form of rubber, and under unusual conditions has crystallized it from ether solution at 40 to 65 degrees below zero centigrade. Other experimental mills for producing industrial products include the cement mill, optical glass furnaces, clay products mill and kiln, foundry, draw bench and others—an ensemble forming an industrial plant not operated for the market but in the interest of the maker and user of the respective materials, applying science to qualify production.

The Bureau of Standards, perhaps the first in which pure and applied science united on equal terms, stood alone in this country at the beginning of this century. To-day 1,620 research laboratories are listed. Many were inspired and aided by the Bureau. On the frontiers of knowledge these laboratories yield numerical data, new materials, new devices, new processes, thus creating industry for to-morrow.

Research results at the Bureau have been many, valuable and interesting beyond even sanguine anticipations—technique for producing and dimensioning high precision gage blocks, strengthening paper, producing semi-commercially a sugar new to industry, development of the radio direction finder, radio-beacon and blind landing system, use of light



EXPERIMENTAL PAPER MILL

IN WHICH ALL CONDITIONS MAY BE HELD CONSTANT OR SEPARATELY VARIED AT WILL.

waves to graduate standards of length, these and hundreds of other results have been reported in Bureau publications, some 2,000 of which have been issued. A descriptive catalog contains an abstract of each and a consolidated subject index of all published work of the Bureau. The value of accurate numerical data has made the Bureau a key institution in many technical fields. Its successes will be recounted in a series of articles which will follow this introductory statement.

Testing may be called "standards at work." The Bureau makes thousands of tests, but does not compete with private laboratories. In fact, the Bureau prefers that private agencies make all tests for which they are fitted and for this purpose has published a list of commercial and academic laboratories to aid those in need of testing services. It also cooperates in organizing such laboratories. An example in the field of cement is proving very successful. The Cement Reference Laboratory maintained at the Bureau of Standards jointly by the American Society for Testing Materials and the Bureau of Standards inspects equipment and methods of any private laboratory free on request. This type of service adds repute to competent private laboratories and tends to raise the standard of inspectional and testing work and thus add assurance of the quality of cement delivered on specification.

Tests in great numbers are made for almost every branch of the government service to supply its needs for equipment and general supplies. Test schedules are so voluminous as to suggest a large supply catalogue. Devices as simple as a volumetric flask or complex as an aviation motor are tested to disclose flaws or excellencies. The measured response to service conditions aids the designer to conserve and make further progress, and the Bureau's inspection at the factories and tests in the

laboratory safeguard mill production and assure delivered quality. Factory inspection is made for cement and electric lamps. Tests are made to determine fitness for use or to settle disputes, the latter umpire tests being undertaken only if both parties agree to abide by the result. A useful type is the developmental test which aids the producer to measure the performance of new or improved materials, devices, and instruments. This, in fact, is one of the great benefits of the work to the ultimate consumer since it enables the Bureau to encourage increased serviceability by pointing out where improvement is needed. Some have thought the Bureau should commend specific brands, but those qualified to know believe that specific advice would be of prohibitive cost to secure and might be nullified overnight by changes in production methods or design.

The public as the ultimate consumer is directly aided by the Bureau's certification and labeling plans under which manufacturers agree to certify that their products meet the specifications of the Federal Government. Lists of firms willing so to certify are furnished to federal, state, county and municipal officials making purchases from tax money, and to others only upon specific request from the individual.

Bureau results are varied and have appropriate outlets for each type. Its staff is widely represented on technical committees of national societies and carries the latest findings into actions by these societies and this knowledge thus enters practice. Visitors in growing numbers come to the Bureau to confer with its experts on problems of industry and carry away with them what the Bureau has to offer. Letters in large number are answered, giving information sought. Letter circulars, several hundred in number, cover topics of unusual public interest, serving a function midway between an especially typed letter and a printed publication. Finally, for the world and posterity, printed publications tell the story of the Bureau's varied activities.

The annual report gives by funds a brief yearly summary of achievements.

EXPERIMENTAL SPINNING MILL

The *Journal of Research* publishes research results, the *Technical News Bulletin* covers concisely all significant activities of the Bureau, the *Commercial Standards Monthly* prints special articles and current news of standardization, while the "Standards Yearbook" sums up world progress in standards and standardization as an annual work of reference and historical record of this world wide movement. Circulars of the Bureau contain announcements, compiled data and general information. Simplified Practice Recommendations promulgate the simplified schedules of reduced number of sizes or varieties as approved by a substantial majority of the industry. Commercial Standards in like manner promulgate standards of dimension or quality for materials and devices likewise approved by industry. The Miscellaneous series comprises annual reports, conference proceedings, charts, tables. The Handbook series comprises codes or standards of practice in a size convenient for the pocket of the technician in the field.

Later articles in this series will tell specifically how the Bureau of Standards touches American life at vital points, affecting equity in trade, efficiency in industry, accuracy in science, effectiveness in process and procedure. It is a matter of good business and wise statesmanship that it should continue to grow commensurately with the advances in science and technology. In fact, the Bureau of Standards has an important share, in fundamental ways, in promoting such advances.

SCIENTIFIC BY-PRODUCTS OF THE U. S. COAST AND GEODETIC SURVEY

By Captain R. S. PATTON

DIRECTOR, U. S. COAST AND GEODETIC SURVEY

INTEREST in scientific work and scientific discoveries is constantly spreading in step with their practical applications. Because of the present popular appreciation of the values of science, workers in border line fields are impelled to include their work in the category of science, thus greatly widening its range. A further explanation of the broadened scope of science is that the scientific method has become almost universal for attacking the many diverse and difficult problems encountered in our modern life, and many studies and investigations are now classed as scientific which were not so considered a few decades ago.

The Coast and Geodetic Survey is not primarily a scientific bureau but rather an institution of applied science. It does, however, carry on work of considerable scientific value. When the Bureau was organized over a century ago, its task was the very practical one of surveying the coasts and harbors of our country, so that the commerce of the world might find safe passage. This was a mighty task. The need for results was urgent and great. Fortunately, the level-headed man selected for the first superintendent, Ferdinand Rudolph Hassler, could not be stampeded into haphazard decisions and plans. Much ahead of his time in his mental attitude, he approached the task from a scientific view-point and, instead of adopting methods but slightly better than were needed to satisfy the demands of the time, spent several months in studying the best surveying methods then known and in devising and superintending the construction of precision instruments.

As evidence of his wisdom in attacking the problem in this scientific way, it need only be mentioned that the first Hassler surveys meet modern requirements. His work had the solid foundation of adequate accuracy to satisfy future needs. Had he planned to meet only the needs of his time, he would have effected but a negligible saving, and his work would have had to be done over at greater expense in after years.

The Coast Survey, as it was first called, therefore, had a scientific beginning, even though the task assigned was a very practical one, and the inspiration of its first leader gave to the Bureau a tradition of high scientific endeavor which has been faithfully maintained. Some of its present valuable scientific by-products may be attributed to this tradition.

The work of the Coast and Geodetic Survey is still of a practical nature. Although its activities have increased many fold, none of its measurements or investigations is for purely scientific purposes. Its magnetic measurements are made to promote the safety of the mariner and to make it possible to retrace old surveys; not primarily to furnish data for theoretical studies of the earth's magnetic field. The measurements of tidal fluctuations and tidal currents are made for the prediction of tidal phenomena as an essential aid to the navigator; Harris's classical theories of the tides, a great addition to the scientific knowledge of the earth, are by-products. Gravity measurements are required to disclose the exact shape of the earth in order that geodetic surveys, which cover such large areas that the earth's exact curvature must be known, may be made with the necessary refine-

F. R. HASSLER

THE FIRST SUPERINTENDENT OF THE U. S. COAST SURVEY.

ment. It is only incidental that the theory of isostasy was confirmed and reasonably established by means of geodetic data already at hand for the control surveys of the country.

These are typical examples. Many more could be cited to show how the practical work of the Coast and Geodetic Survey has resulted incidentally in yielding scientific data of great value.

In 1878, the designation of the Bureau was changed to Coast and Geodetic Survey. Its most important work still remained the survey of the coast, but its geodetic activities had become considerably expanded. To coordinate the charts of the Atlantic and Pacific coasts, an arc of triangulation across the entire country was essential and the great arc along the 39th parallel, over 2,000 miles long, was carried out.

Before the positions of the stations along this arc could be accurately computed, it was necessary to determine the elevations of the stations at the ends of the various base lines in order that all lengths of the triangulation could be reduced to a common datum plane. Lines of levels were therefore run and the elevations above mean sea-level de-

termined for a large number of permanent points called bench marks.

Engineers and surveyors immediately recognized the value of these precise geographical positions and accurate elevations and wherever possible began to connect local with the more comprehensive national surveys, creating a demand for extensions of the control surveys into other parts of the country.

A similar expansion of the magnetic work of the Bureau took place at about the same time. The magnetic part of the Bureau's activities, begun in 1843, had for its purpose the furnishing of much needed information to navigators and surveyors about the behavior of the magnetic needle.

The magnetic needle, as is well known, is very erratic and does not in general point true north. Its deviation varies from place to place and from day to day. It even has an hourly variation and a special variation due to magnetic storms.

When land was cheap, property and boundary lines were almost universally laid out with a compass, with the corners sometimes not marked at all or often poorly marked. After property became more valuable, the surveyor retracing these lines had to determine the deviation of the needle at the particular time of the original survey. This information was ordinarily available only in case comprehensive magnetic surveys extending over a number of years had been made covering the area in question.

The safety of navigation depends to a very great extent upon the compass and the navigator's knowledge of its behavior. Like the surveyor, the navigator must know the variation of the needle from true north, but in addition he must also know to what extent his compass is affected by the iron in his ship. The latter is a difficult problem and its solution requires a knowledge of the dip (inclination) and the intensity of the earth's magnetic field.

Altogether, to meet the needs of the navigator and the surveyor and now of the aviator, a great mass of data had to be collected. These data are useful not only for the particular purposes enumerated above but have great scientific value. In conjunction with similar data over the oceans, collected chiefly by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, they made possible extensive investigations of the earth's magnetic field, and of possible correlations of magnetic variations and storms on the earth with sunspot activity and other important studies. Although these intensive investigations are mostly carried on outside the Coast and Geodetic Survey, they depend in part for their accuracy and the wide range of problems they cover upon the data accumulated by this Bureau.

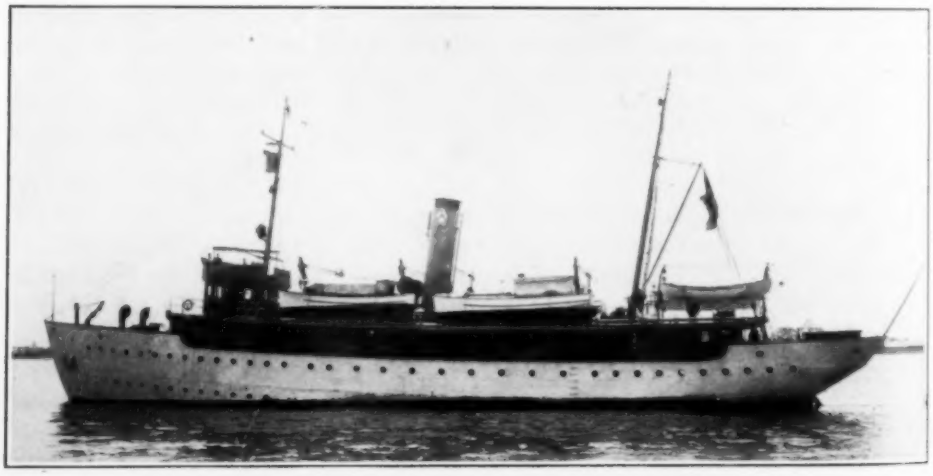
The seemingly diverse major activities of the Coast and Geodetic Survey are related, as an enumeration of them will show. Perhaps the first item in our enumeration should be geodetic astronomy, for before any accurate survey can be made, starting points must be established and true directions to other points determined by astronomical observations. Latitudes, longitudes and azimuths, determined astronomically, may therefore be compared to the foundation of a building. They serve as a beginning for all other surveys.

Next in our enumeration should come triangulation, because that is needed next. The geographic positions of a large number of points are required as a basis for hydrographic, topographic or other surveys. To make astronomical observations at every station would require too much time and expense. Even then, the results would not be satisfactory. Astronomical observations are affected by deflections of the verti-

U. S. COAST AND GEODETIC SURVEY STEAMER *EXPLORER* AT PRINCE WILLIAM SOUND, ALASKA

cal, so the exact relative positions of points on the ground can best be obtained by triangulation. Base line measurements should be included with triangulation, since they furnish the starting and check lengths at intervals through an arc.

Hydrographic surveys should be mentioned next. Knowing the positions of triangulation stations on shore, the hydrographic engineer determines the position of his sounding boat and soundings. As the depths read on the sounding line depend upon the tide, the variations of the height of the tide must be measured at points along the shore and a uniform datum plane established to which all soundings are referred. Tide and current observations are required, of course, further to insure safe



COAST AND GEODETIC SURVEY STEAMER *SURVEYOR*

navigation along the coast and in harbors. Hydrographic operations likewise include wire drag surveys, by means of which pinnacle rocks and other hidden dangers, missed by the sounding line, are discovered.

The magnetic work of the Coast and Geodetic Survey has already been mentioned and its purpose briefly described. The final item in our enumeration is the seismological work of the Bureau. This covers not only the recording of earthquake shocks at a number of field stations and the location of epicenters from data sent in by these and other widely scattered observatories, but includes also the periodic redetermination of geographic positions and elevations to detect earth movements in seismic regions.

It may be asserted that all the activities enumerated above are carried on with scientific accuracy; an accuracy permitting the results to be used with confidence for scientific studies and investigations. There is no danger of the conclusions reached being in error because of uncertainties in the original data, beyond those due to unavoidable observational inaccuracies.

In what ways are all these data, so carefully collected, used for scientific purposes? Let us consider a few.

The Coast and Geodetic Survey publishes over 700 different charts of the waters under the jurisdiction of the United States. Over 277,000 of these charts were distributed during the last fiscal year. The data actually shown on each chart is only a small fraction of that used in its construction. To obtain the delineation of the bottom of a harbor or of the waters along a section of the coast, the hydrographic engineer must make a great number of soundings. Only a few of these can be placed on the chart in the space allowed without making it so confusing as to destroy its value. As the critical or characteristic depths are useful to the navigator, they are the only ones shown on the finished chart. A count of the field records used in compiling a typical single chart showed that information needed in its production appeared in 469 field sheets, sounding and tidal records and volumes of data.

SURVEY PARTY LANDING THROUGH SURF

When the data needed to produce one chart are multiplied by more than 700, the total is enormous. But we must go even beyond that. Certain sections of our coasts are sandy and the action of

RADIO ROOM ON SHIP *GUIDE*

SHOWING INSTRUMENTS AS SET UP IN RADIO ROOM. THE ORIGINAL EXPERIMENTAL WORK IN R. A. R. WAS DONE BY THE SHIP *Guide*.

winds and waves constantly builds new shoals and reefs, tears out old ones, and changes the location and characteristics of the shore line. New roads and streets are constructed along the shore, in the harbors new wharfs are built or changed along the water fronts, and new or deeper channels are dredged. New surveys must therefore be made from time to time to determine these changes, necessitating revised editions of charts. The number 700 therefore represents only a fraction of the total number of charts, if separate editions based on new surveys are included.

For what scientific purpose are all these data useful? The first that comes to mind is the problem of coast erosion. While this has a very practical side in connection with the protection of waterfront property or the building up of new land, it has also a scientific side. How is erosion affected by the configuration of the bottom, the character of the material underlying adjacent water areas, the presence of outlying reefs, the prevailing direction of the wind, the oceanic and tidal currents, or the temperature or salinity of the water? A comparison of a series of revised editions of charts of a particular area shows exactly what changes have taken place in shore line, channels and reefs, and character of the bottom, and if the charts do not give sufficient detail, field sheets and other original survey data are available in the Bureau.

Much of the data needed for a scien-

FLOATING SIGNAL FOR OFFSHORE HYDROGRAPHIC SURVEYS

tific investigation of the problem, therefore, are furnished by the surveys of the Coast and Geodetic Survey. Although only a bare beginning has so far been made on coast erosion investigations, the problem will undoubtedly be studied intensively in the future.

Geologists for a long time have been interested in the continental shelves. What explanation can be given for these shelves? Are they rising or sinking, and are they affected by the weights of sediments deposited on them by rivers? A study of the charts covering these shelves show what are apparently the remains of old river valleys that are now submerged. Some investigators detect the results of glacial action on the continental shelf off New England. Tidal data show whether there is any tendency of at least the shoreward side of the shelf to rise or sink. Large changes in depth on other parts of the shelf are revealed by a comparison of soundings made at different dates, provided the character of the evidence is such that the changes found need not be attributed to other causes. Considerable scientific study has recently been given to continental shelf problems, based to a large extent on Coast and Geodetic Survey data.

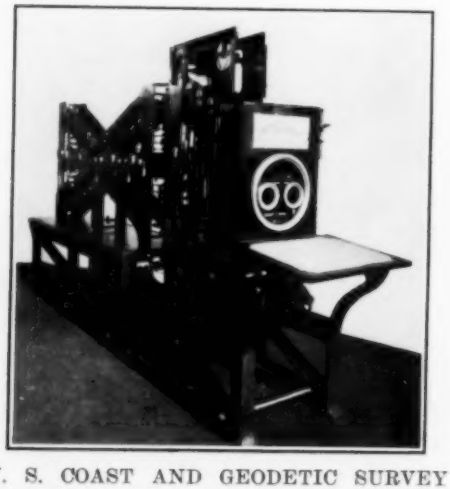
During the past few years much study has been given to the question of the velocity of sound through sea water. An important reason for this study has been two new developments in hydrographic surveying methods, one an improved method for sounding in deep water, and the other a more accurate method for determining the position of a surveying ship at such a distance from shore that land is no longer visible. The accuracy of the results obtained by either method depends upon a precise knowledge of the velocity of sound through sea water under different conditions of temperature, salinity, etc.

The new method for sounding in deep water is called sonic sounding. A

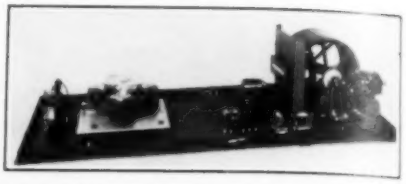
PLANE TABLE SURVEYING IN SOUTHEASTERN ALASKA

PARKHURST THEODOLITE

THIS INSTRUMENT IS USED TO MEASURE THE ANGLES OF TRIANGULATION. SCIENTIFIC ACCURACY IS OBTAINED IN THE MEASUREMENTS MADE WITH THIS INSTRUMENT AND THE WORK CAN BE DONE VERY RAPIDLY.



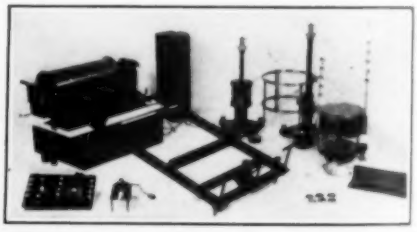
U. S. COAST AND GEODETIC SURVEY TIDE PREDICTING MACHINE



ACCELEROGRAPH FOR USE IN REGISTRATION OF STRONG SEISMIC MOTION. THIS COMPLETE UNIT CONSISTS OF A THREE-COMPONENT WENNER ACCELEROMETER, PHOTOGRAPHIC RECORDER, TIME MARKING CLOCK AND A TWO-COMPONENT STARTING ACCELEROMETER OF THE TYPE DEVELOPED AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

sharp sound emitted from the ship is reflected back as an echo from the ocean bottom. If the time required for the sound to travel to the bottom and back is accurately recorded, the depth of the water can be computed.

The method for fixing a survey ship's position when out of sight of land is called radio acoustic position finding. A bomb is exploded under water near the ship and the sound waves, traveling through the water, operate hydrophones at known points along the shore. The hydrophones, in turn, trip radio transmitters, each of which automatically sends a radio signal back to the ship. Since radio waves travel with the velocity of light, the time interval between the bomb explosion and the return radio signal is essentially the time required



MAGNETOGRAPH AND EQUIPMENT OF THE LA COUR TYPE

AS USED AT THE COLLEGE-FAIRBANKS POLAR YEAR STATION, COLLEGE, ALASKA, FOR REGISTRATION OF THE VARIATIONS IN THE EARTH'S MAGNETIC DECLINATION, HORIZONTAL INTENSITY AND VERTICAL INTENSITY.

for the sound wave to travel from the ship to the shore station.

One phase of radio acoustic position finding requires scientific investigation beyond the study already given to it. The path followed by the sound wave in going from ship to shore is not yet definitely known, or a better statement of the problem would be that the path followed by that part of the sound wave which first reaches the hydrophone is not definitely known. The velocity of sound is different near the surface from what it is near the bottom, and the accuracy of the position determined by this method depends upon how nearly the actual sound path can be ascertained.

There are of course other important scientific investigations which are based on the hydrographic data of the Coast and Geodetic Survey. There are also a number of outstanding problems, the solutions of which are dependent upon other kinds of data collected by the Bureau. Let us consider a few of them.

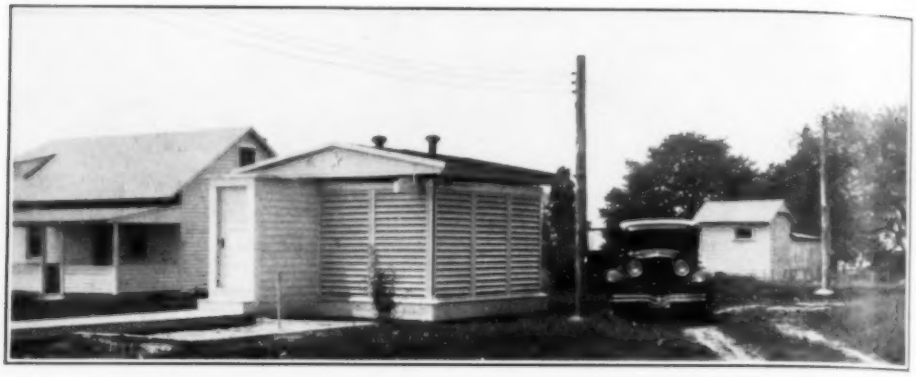
Mention has already been made of the effect of deflections of the vertical on astronomical observations. Ever since Newton's time the laws governing the attractions of bodies of matter have been known to a high degree of approximation. With these laws and a sufficient knowledge of the topography of the earth it should be possible, theoretically, to compute for a given point on the earth just how the bob of a plumb line will be attracted by the earth's mass as a whole. If there is a mountain a certain distance from the station in a given direction, we know the attraction of the mountain will pull the plumb line slightly to one side. If the size and distribution of mass of this mountain are known, its effect on the plumb line can be computed.

A strange thing was noticed many years ago when attempts were made in India to compute the attractive effects of mountain masses. The apparent

BROWN GRAVITY APPARATUS

THIS IS A NEW TYPE OF PENDULUM APPARATUS RECENTLY DEVELOPED BY THE COAST AND GEODETIC SURVEY. RESULTS OBTAINED WITH IT IN WYOMING DURING THE FALL OF 1932 HAVE BEEN OF GREAT SCIENTIFIC INTEREST TO GEOLOGISTS WHO ARE STUDYING THAT REGION.

THE FATHOMETER. AN INSTRUMENT FOR ECHO SOUNDING



LATITUDE OBSERVATORY, GAITHERSBURG, MARYLAND,

ONE OF TWO OBSERVATORIES IN THE UNITED STATES OPERATED BY THE COAST AND GEODETIC SURVEY UNDER INTERNATIONAL AGREEMENT FOR THE SCIENTIFIC STUDY OF THE VARIATION OF LATITUDE. THE RESULTS ARE COMBINED WITH THOSE FROM SIMILAR OBSERVATORIES IN OTHER PARTS OF THE WORLD.

actual attraction of a mountain was found to be much less than the computed effect. The only explanation found for this lack of attraction was that there must be some form of compensating negative mass underlying the mountain. This theory, in two different forms, propounded about the middle of the nineteenth century by two famous English geodesists, Pratt and Airy, later became the basis for the well-known isostatic theory.

Early in the twentieth century, a quantitative test of the isostatic theory in the Pratt form was made by the Coast and Geodetic Survey. It was assumed that the crust of the earth above a uniform imaginary surface about seventy miles below sea-level is in floating equilibrium, that is, that a mountain is balanced by an equal negative mass directly below, and that an ocean is balanced by an equal positive mass below it. Computations showed the theoretical deflections of the vertical on this basis were remarkably close to the actual observed deflections. Several hundred astronomical stations were used in this investigation and the results were almost conclusive proof of the main essentials of the isostatic theory.

The practical result of this investigation was that the Survey was able to derive the shape of the earth so accurately that its mathematical spheroid was adopted as the standard international ellipsoid to be used as the basis for triangulation computations and adjustments.

Later the Survey applied the isostatic theory to the computation of the intensity of gravity, again strikingly demonstrating the general truth of the isostatic theory. Theoretical values of gravity computed on this basis came much closer to actual observed values than by any other method proposed for the computation of gravity. The first immediate practical result of this investigation was a check on the shape of the earth as derived from astronomical data. Another important result was the theory that some indication of the kind of material concealed in the upper part of the crust could be obtained by comparing values of gravity computed on the isostatic theory with actual observed values. If the computed value of gravity is too large, the station is probably above a mass of rock of density less than normal; if too small, it is probably on a mass of heavy rock. As

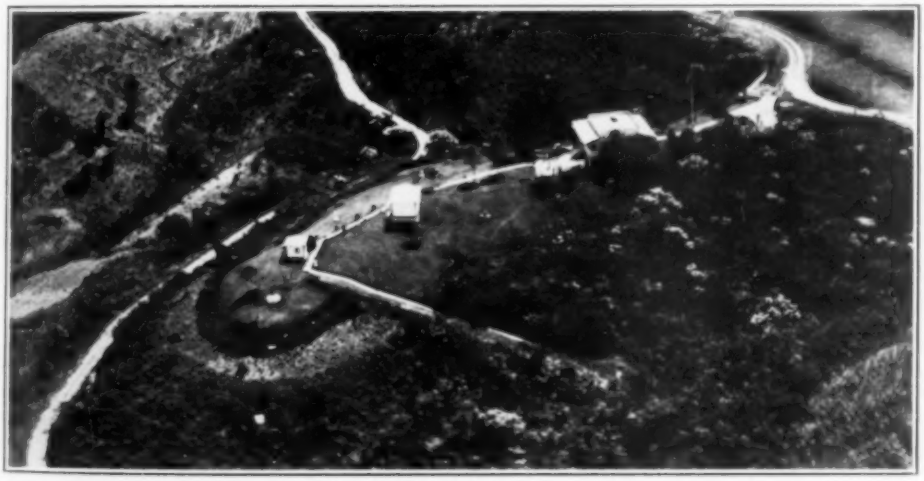
a result of this discovery the gravity method is now used in conjunction with other scientific methods in the search for oil and minerals.

The isostatic theory has been tested on both land and sea in many parts of the world, and has not only been definitely proved to be an accurate workable theory of the earth's crust, but it has also served as the basis for certain geological investigations, as, for example, the effect of glacial loading and unloading on the elevation of the underlying crust, the relation of synclines to heavy rock formations, and the effect of erosion and sedimentation on the equilibrium of the earth's crust. Accordingly, our knowledge of the interior of the earth has been increased very considerably by means of the isostatic method of attack.

I should again touch on one of the more recent activities of the Coast and Geodetic Survey, namely, its seismological work, formally assigned to the Bureau in 1926. Seismographs had already been in operation at its magnetic observatories for a number of years. It had been suspected that the magnetic records at the observatories were affected at times by earthquake disturbances. It was therefore necessary to record earthquakes in order that the magnetic measurements might be freed of their effect. The seismograms thus obtained were also found very valuable for earthquake study and consequently were made available for the use of seismologists. Here again we see a very practical need underlying the collection of data which later proved to have scientific value.

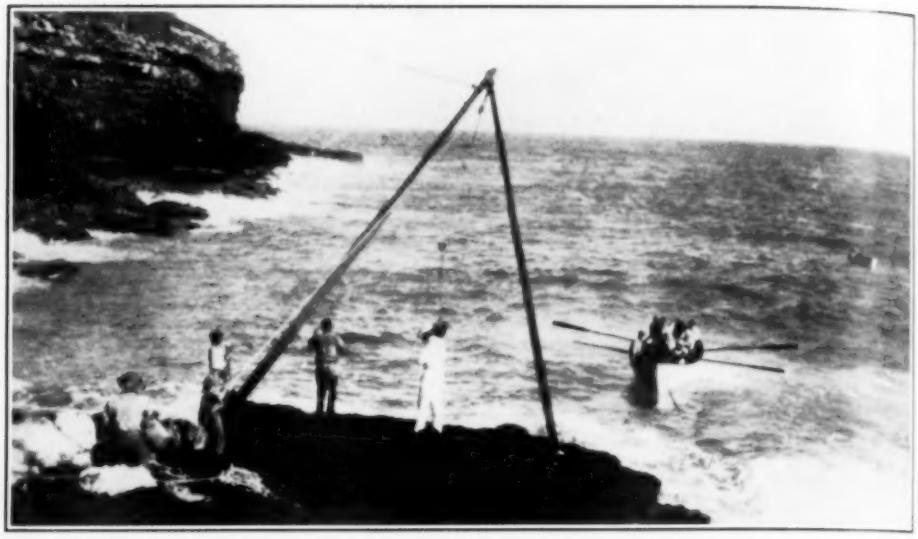
The Coast and Geodetic Survey now obtains earthquake data not only from its own observatories but from a number of cooperating organizations in this country and abroad. It determines the positions of earthquake epicenters from these data and publishes results at regular intervals. It has installed new and better types of instruments at its observatories and the data collected are constantly becoming more comprehensive and valuable.

Why study an earthquake after the damage has been done? Perhaps the



AIR VIEW OF THE SAN JUAN MAGNETIC OBSERVATORY,

NEAR SAN JUAN, PORTO RICO, AT WHICH CONTINUOUS PHOTOGRAPHIC RECORDS OF THE EARTH'S MAGNETIC ELEMENTS ARE MADE. THE COAST AND GEODETIC SURVEY OPERATES FIVE OF THESE OBSERVATORIES WELL DISTRIBUTED OVER THE UNITED STATES AND POSSESSIONS.



LANDING ASTRONOMIC AND GRAVITY INSTRUMENTS AT NIHOA ISLAND OF THE HAWAIIAN GROUP

best general answer to this question is that we are rapidly increasing our technical knowledge of earthquakes and there can be no doubt that this knowledge eventually will be of great value in helping mankind to minimize the detrimental effects of such disturbances. Investigators are learning where earthquakes are most likely to occur, what kinds of waves are produced in the ground near the epicenter and how these waves travel, what buildings are most likely to resist shocks, and what changes occur in the positions and elevations of points on the ground before, during and after the shock.

An interesting scientific study of the interior of the earth is possible from seismic data. An earthquake shock is recorded at distant points because of earth waves emanating from the epicenter. These waves are of two different types and travel along several different paths near the surface of the earth and through the interior. A great deal of our present knowledge about the crust of the earth and the so-called central core has been obtained by a study of earthquake records. Much has been learned about the speed of travel of the different waves along the various paths, and the relation of the speed to the elasticity and other properties of the rock through which the waves pass. This knowledge has been applied by geologists to the search for oil and other minerals by the simple expedient of making use of artificial earthquakes suitably located and produced by explosions.

In preparing this paper I have purposely avoided giving any technical details of the work carried on by the Coast and Geodetic Survey. My purpose has been to present a general picture of a broad field and to leave it to the reader to pick out the subject in which he is most interested and then obtain the details from a more technical treatise. I trust I have shown that the work of the Coast and Geodetic Survey, done primarily to meet practical, every-day needs, contributes in a very real sense to an increase of the scientific knowledge of the world, without which mankind can not expect to advance.

CAJAL'S SUGGESTIONS FOR THE SCIENTIFIC INVESTIGATOR

By Dr. WILLIAM A. HILTON

PROFESSOR OF ZOOLOGY, POMONA COLLEGE

S. RAMON Y CAJAL is especially well known to the histologist and neurologist for his most important contributions to our knowledge in the field of the nervous system and sense organs. Few men in science have received such complete recognition during their lives and none have more justly come by these honors. Besides his numerous technical monographs and books are a few others of a more literary character. He has kindly granted me the privilege of drawing freely from two of these in connection with an account of his life. They are his autobiography and "Rules and Counsels for Scientific Investigation." This last has so much of interest and value that I have translated from the Spanish some of its striking passages before a more comprehensive work is published.

On the whole Cajal is appreciative of the value of philosophy, but he says:

". . . . The history of civilization has unmistakably demonstrated the sterility of metaphysics in its repeated efforts to divine the laws of nature. It has been rightly said that the human intellect, turning its back to reality and concentrating in itself, is powerless to explain the most simple mechanisms of the world and life."

". . . . I think myself that the slight benefit derived from the reading of such works and in general of all works concerning the philosophical methods of investigation, results from the vagueness and generality of the rules that they contain; when they are not empty formulae, they come to be the formal expression of the mechanism of thought in the investigating function. This mechanism acts unconsciously in every mind regularly organized and cultivated; and when by an act of meditation the philosopher formulates his psychological laws, neither the author nor the reader can by their use improve his respective capacities for the scientific investigation. The expositions of logical methods cause in me the same impression that would be produced by an orator that pretended to increase his eloquence through the study of centers of voice production and the mechanism and innervation of the larynx, as if knowledge of these anatomic-physiological devices could create an organization that we lack or perfect the one that we have."

"It is important to note that the most brilliant discoveries have been due not to the knowledge of written logic, but to that living logic that man possesses in his spirit, with which he elaborates ideas with the same perfect unconsciousness with which Jourdain spoke prose."

He declares that there are no logical receipts for making discoveries.

"The men of genius hardly bow to written rules; they prefer to make them. As Condorcet says: 'The mediocre can be educated, but genius educates itself.' "

However, Cajal suggests that if we abandon vague philosophical principles and abstract methods, we may find the "moral and instrumental technique indispensable to the inquisitive process; it will be easy to find some rules positively useful to the beginning investigator." It is to the *will* more than to the intelligence that his suggestions are directed. He has the belief that the first is as capable of education as the second and also that every great work, in art, in science, is the result of a great desire.

"Excessive devotion to genius has its

root in a double sentiment of justice and modesty which is hardly to be blamed, but if it takes too great possession of the beginning investigator it destroys all initiative and incapacitates him for original investigation. Defect for defect, arrogance is preferable to bashfulness. Boldness tries its strength and conquers or is conquered, but excessive modesty avoids the battle and condemns itself to shameful inaction. . . .

"Far from becoming discouraged before the great authorities of science, the novice in investigation ought to know that his destiny by a cruel, but inexorable law, is to grow a little at the cost of the reputation of the great authorities. . . .

"But it is not necessary to destroy; it is necessary to build. Scientific criticism justifies itself, delivering in place of an error a truth. Commonly the new doctrine will come out of the ruins of the abandoned and will find itself resting on the facts rightfully interpreted."

Recent graduates, so Cajal says, are often heard to express such sentiments as these:

"All the substance of each scientific theme has been exhausted. Of what use is it for me to add some small detail? How can I hope to reap where more diligent observers have already collected abundantly? . . . .

"So speaks laziness, many times masquerading as modesty. That is the way some youths of merit think when they feel the first dismay produced by the consideration of a great enterprise. . . .

"In general it can be affirmed that problems are not exhausted, but men are exhausted in a problem. Fresh talent arriving without reputation to the analysis of a subject will always find a new aspect, something that was not noticed by those who definitely abandoned the subject. So fragmentary is our knowledge that even in the most studied topics there are unexpected findings. . . .

"In the struggle with nature, the biologist and the astronomer must do away with the earth which he inhabits and concentrate his attention upon the severe region of the idea where sooner or later the light of truth will appear. The new fact established, the applications will come in their time."

Cajal believes that many who declare themselves lacking in ability for scientific research are those who take this attitude to explain their laziness. Those not fitted for this work would be: "those not capable of prolonged attention and lacking curiosity or admiration for the works of nature."

Patience, ability for details, constancy, may be acquired, "with the habit of work and the satisfaction of success." Many of medium qualities may do something for as he says:

"Science like the army needs generals and soldiers, some to conceive the plan, others to work out details. . . .

"A dominant characteristic in the eminent investigators is the high, proud independence of judgment. They do not fall surprised and confounded before the work of their predecessors and teachers but remain impatient and inquisitive. . . .

"Men of science are moved by the same impulses as others, but two dominating forces are clearly seen, 'the cult of truth and the passion for glory.'"

". . . . the sincerest and the most devoted scientist remains profoundly human; in his life for his fellow beings he exceeds the best, expanding his usefulness beyond present and local conditions. Thanks to these men of singular talent whose sight penetrates into the shadows of the future, and whose exquisite sensibility makes them regret the errors and the stagnation of routine, in scientific progress only the genius can have the privilege of opposing the current and modifying the moral medium. His mission is not the adaptation of his ideas to those of society but the

adaptation of society to his ideas, and if he is right (as he usually is) and proceeds with prudence and energy, without dismay, sooner or later humanity will follow him, applaud him and cover him with glory. Trusting in this pleasing tribute of veneration and justice, every investigator works with confidence because he knows that if individuals are capable of ungratefulness, communities very seldom are if they reach full consciousness of the reality and utility of an idea.

"It is a very common truth that in a variable degree the desire for approbation and applause moves all men and especially those endowed with a great heart and wondering mind, but each one searches for glory by a different road. One is a soldier with the arms so celebrated by Cervantes in his Quixote and another aspires to increase the political greatness of his country. Others through art are desirous of the easy applause of the multitudes that understand beauty much better than truth. A few only in every country and in the more civilized, follow the path of scientific investigation, the only way that can bring us to a rational and positive explanation of man and of nature which surrounds him. I think that this aspiration is one of the most dignified and laudable that man can follow, because perhaps more than any other it is impregnated with the perfume of love and universal charity. . . .

"It is considered important that the beginner know thoroughly the literature of his field, not alone must he depend upon printed information but he must constantly return to nature herself. He must know in a general way all the other sciences which directly or indirectly have connection with the selected field. . . .

"The inquisitive mind is like a weapon of combat. If it is sharpened on one side only we shall have a cutting sword, if on two sides it will still be able to cut but less efficiently, but if we sharpen it on three or four edges, we diminish its effectiveness until it is converted into an inoffensive quadrilateral. A bayonet could, if necessary, cut, but not without considerable motor energy, while a knife sharpened on one edge is terrible in the hands of a baby. . . .

"A knowledge of the German language is indispensable for one who would be up to date in a knowledge of current science. After the German, English and French follow in importance.

"We learn much from books, but we learn more in the contemplation of nature, cause and occasion of all books."

"All descriptions, no matter how objective and ingenious, they might seem, constitute the author's personal interpretation. It is known that a man mixes his personality with everything and when he thinks he is photographing the external world he frequently contemplates and pictures himself."

"On the other hand observation furnishes, besides the empirical data with which we have to form judgments, certain emotional factors as: surprise, enthusiasm, agreeable sentiments, that are propelling forces of the constructive imagination. The emotion lights the cerebral machine which acquires by it necessary heat, the forge where fortunate intuitions and hypotheses will be wrought. . . .

"After choosing the theme of study and being informed in detail if possible of the actual state of the point to be elucidated, the investigator will pass on to apply as many analytical methods as have been proposed, with the object of confirming the facts described and reproduced in the most recent monographs."

"Among the procedures of study will be chosen by preference the most recent ones, and above all, the most difficult, because they are the least exhausted. The time spent in fruitless essays matters little, for if a method offers great differentiating powers the results obtained

will have great importance and will abundantly repay our efforts. . . .

"The new idea found is frequently the fruit of patient and tenacious observation, the consequences of having applied to the theme more time, more constancy and the best methods of one's predecessors. . . .

"The first fact conquered, our task will be as easy as brilliant, for it will reduce itself to progressively determining the consequences that the new acquisition has in different spheres of science. It has been said that although the first discovery is hard, the others are usually corollaries of the first. . . .

"The explorer of nature, we repeat it several times, must consider investigation as an incomparable sport, in which everything from the technical procedure to the doctrinal elaboration constitutes an eternal fountain of grateful satisfactions. . . ."

Diseases of the Will: This is one of the most interesting parts of the book. I can not do better than quote parts of the first two paragraphs of this chapter.

"We have all seen teachers superiorly endowed, overflowing with activity and initiative, possessors of sufficient means for investigation and yet who do not realize the value of personal work and never write. Their disciples and admirers await with anxiety the 'Great Work' which will justify the high concept of the teacher that they have formed; but the important monograph is not produced and the teacher continues without writing a word."

"Let us not be deceived by optimism and good will. Despite the exceptional merit and zeal and the energy shown in certain teaching activities, such teachers have diseased wills." Cajal divides these into several groups:

Contemplators: He begins with the sleepy variety, frequent among anatomists, chemists, biologists and physicists. It is recognized by the following symptoms:

"Love for the contemplation of nature, but only in its aesthetic manifestations, the sublime spectacles, the beautiful forms, the splendid colors, and the elegant structures. If the dilletante is a botanist, he will always remain anchored to an admiration of Algae, especially the diatoms, whose beautiful shells will captivate his admiration. In his fetishist cult he will spend his hours examining and photographing in a thousand ways, these interesting organisms, comparing them with Greek letters, shields, and other ornamental objects, but without adding to the copious catalogue of the known species a new variety, or contributing in the least to the knowledge of the structure, evolution and functions of the mentioned organisms."

Bibliophiles and the polyglots: "As the microscopist takes pleasure with the diatoms, the zoologist with shells, insects and birds of showy livery, the bibliophile will enjoy himself by reading very new books or monographs, or such transcendental writing from which he cares to receive only that which will astonish his friends with his vast knowledge."

"The symptoms of this ill are: encyclopedic tendencies, acquisition of many languages, some of them totally useless; exclusive subscription to little-known reviews; monopolization of as many new books as appear in the windows of book stores; assiduous reading of what is important to know, but especially that of interest to few, invincible laziness for writing and aversion for the seminar and the laboratory."

"As is natural our erudite lives in and for his library, which is copious and monumental. He receives there those of his kind, to whom he engages in pleasant conversation with disconnnected questions such as "Have you read this book?" (Here it may be a Yaqui, German, Russian or Scandinavian name.) "Do you know the surprising theory of so and so?" And, without hearing an answer, the erudite develops, with warm

eloquence, a doctrine which is usually extravagant and audacious. All his eagerness is to pass as a monster of talent and of culture without thinking that only living effort can save the scientist from forgetfulness and injustice."

"There is not, fortunately, need of insisting much on this point to rectify mistaken social judgments. No one ignores the fact that the one who knows and does is valuable compared to the one who knows and goes to sleep. We render tributes of veneration to the one who adds an original work to a library and we deny it to the one who carries a library in his head. To become a phonograph, it would hardly be worth while to have the brain complicated with study and reflection."

The Megalophiles: "This variety is characterized by miscarried noble and sympathetic attributes. They study much and also love personal work; they possess the cult of action and dominate the inquisitive methods; they overflow with sincere patriotism and desire to honor their name and their country with admirable conquests."

"But nevertheless a remarkable error sterilizes their efforts. Convinced evolutionists in theory they are really providentialists in practice. As though they had faith in the miraculous they wish to start with a great deed. Remembering perhaps that Herz, Mayer, Schwann, Roentgen, Curie, initiated their scientific life with a great discovery, they aspire to ascend after the first battle from soldiers to generals, and they spend their lives planning and drawing, constructing and rectifying always in feverish activity, always in full revision, incubating the great product, the astonishing and overwhelming work. The years go by, expectation grows tired, competitors murmur and friends force the imagination to give an honorable appearance to the silence of the great man. And in the meanwhile, on that theme so carefully explored and canvassed, there comes an important monograph from a foreign country, which snatches from our ambitious investigator the flattery of priority and forces him to a change of direction."

Organophiles: "These are known by a kind of cult or fetish for the instruments of observation. Fascinated by the shining of the metal as the lark for the mirror, they take loving care of their idols, which they keep sacred, brilliant as mirrors and admirably preserved. Repose and content reign in the laboratory where there is not a stain seen or the least murmur heard."

"In the large pockets of the organophiles keys sound continually. It is impossible for the assistant or students in the absence of the professor, either to study the monographs or use the necessary apparatus. Microscopes, spectroscopes, balances, reagents, etc., are kept and sealed seven times! Nothing worse could happen, or be more greatly punished by the chief of the laboratory, than to have the assistant spoil the objective of Zeiss, the refractometer, the polarizer. That would be horrible! Besides, is he not the only one responsible for the scientific material, sacred chest of the University? And will he not some day have to render exact account to his superiors? Investigate? Confirm? He will do it when he has time, and when certain new monographs that are indispensable have arrived. Alas! If the Government would increase the budget for material, perhaps he would be able to spare, in the interests of teaching, part of the sacred deposit. But in the meanwhile! ! !"

Those out of line: "The profession of teaching is at times a mere step to that of politics or an advertisement for professional work. . . ."

The Theorizers: "These are the cultured and superiorly endowed whose will suffers from a kind of laziness more grave because it does not seem such to them, nor to others. Here are the principal symptoms: talent for exposition;

unrestful and creative imagination; separation from the laboratory and inevitable antipathy towards concrete science and detailed facts. They prefer to see things large and live in the clouds. They prefer the book to the monograph and the brilliant and audacious hypothesis to the classic but solid conception. In the presence of a difficult problem, they feel an irresistible temptation, not to ask of nature, but to form a theory. If they happen to perceive a weak and artificial analogy between two phenomena, or succeed in putting the new fact in the frame of a general conception, true or false, they feel satisfied and they continue to believe themselves superior reformers. The method is legitimate in principle, but they abuse it, falling into the innocence of considering things under a single aspect. To them the essential is the aesthetic side of the conception. It matters little if it melts in the air, as long as it is beautiful and ingenious, profound and symmetrical. In reality the theoretical individual is a lazy person disguised as diligent. . . ."

Social conditions favorable for scientific work: Much of the material under this heading applies to conditions in Spain but there are a few paragraphs I wish to quote.

". . . . He goes on to say that in spite of such discouraged phrases as: "I lack a laboratory; my profession is incompatible with the equipment indispensable for scientific work; family obligations rob one of time and money required by the work of investigation"—that

"It would be easy to reduce to its true value such laments and insist upon this important truth: *for scientific work the means are almost nothing and the man is very nearly everything.*"

"*Difficulties of material means:* This is the convenient excuse which many professors and not a few doctors, not burdened with teaching but able for scientific investigation, present as soon as they are asked about their work. . ."

"*The investigator and the family:* The worries and expense required in the creation and support of a family, in contrast with the poor pay which the state gives the teaching function, constitutes, as is well known, another of the reasons put forward by many of our teachers for deserting the laboratory and devoting their activities to more lucrative enterprises. 'Science and the family are incompatible' they affirm. 'Since the physical basis of the professor is so small, how can he invite some one else to join him to share it? The scientist must choose between his spiritual family and his real family; between his ideals and his sons.' It is correct to recognize it; in such exaggerations there is some truth. The care of the home, like the moral and economic struggle, takes from the work of investigation. The ideal university would be a monastery, whose monks, devoted for life to the study of nature, would have slight distraction from their regular duties.

"But we are too imperfect to consecrate ourselves with equal fervor to noble causes. The desire of heaven takes our interest from earth. It is well known that the psychologists, absorbed in the contemplation of the spirit, depreciate the brain. Those who occupy themselves about the devil laugh at the microbe. And the aspiration to eternal glory separates us from human glory. Glory! Vain illusion, no doubt, but capable of removing mountains and of giving ardent impulse to humanity towards the true and good. Like patriotism, the passion for glory must be suggested and never analysed.

"But the monastic life would result for the majority of scientists in intolerable sacrifice. . . . If woman is an ill, let us admit it, she is a necessary ill. Very few are the austere for whom the beautiful half of the human race represents something like a showy sample of an ornithological collection! Besides, it would be a poor procedure for the win-

ning of followers to offer them abstinence and martyrdom. Let any who can deny himself do it, but let us not impose that on any one."

"*Selection of a companion:* We touch here a very delicate point. What qualities should adorn the one chosen by the man of science? Many citizens suffer from their wives, but they suffer alone; but from the wife of the scientist sometimes society suffers and even the whole of humanity! How many important works have been interrupted by the egotism of young wives! How many vocations have been frustrated by feminine vanity or caprice! How many famous professors surrender to the weight of the matrimonial yoke, converting themselves into common gold finders, degrading themselves and sterilizing their work with the insatiable monopolizing of dignities and privileges."

"Even the most human and noble impulses of the wife, when they reach excessive conditions, constitute formidable enemies of scientific work. As is well known, there exists in the wife the spirit of the family, the saving tendency of the physical conservation of the race. It is wholly egotism since it represents the supreme interest of the species! Not without reason and depth has Renan said: 'What woman wants God wants.' She concentrates her love and abnegation in the family; less exclusive, the man knows how to distribute his efforts between the family and society."

"The woman loves tradition, adores privilege, feels justice little and is usually indifferent to all works of reform and progress; whereas the man truly deserves the title of homosocialist. He abominates routine and privilege, venerates justice, and places in many cases the cause of humanity before the cause of the family. That is why the mother wants to live only in the memory of her sons, while the father desires besides to survive in the pages of history. . . ."

"Arriving at this point, the reader will wish perhaps, that we abandon the field of generalization and define the type of woman more adequate to the man of science. It is not a matter of indifference that the wife be for the man of study a gas that elevates him to the sky or a ballast that obliges him in the best of his life to land in the marsh."

"The intellectual wife, that is, the young woman adorned with a scientific or literary career, who, carried by irresistible vocation for study, has been able to acquire general instruction together with enough that is solid and varied; constitutes a very rare kind in Spain. One must, then, renounce such grateful company. It is sensible, no doubt because the few examples of woman doctors (except two exceptions) whom we have known in laboratories and clubs, seem, with their lack of charm, to console us for their being inaccessible."

"There abounds, on the contrary, in foreign nations, this feminine category, in which the scientific wife stands out with singular prestige, collaborator in the scientific enterprises of the husband, and exempt (as much as possible) from the frivolities and fantasies of the feminine temperament. Such a woman, intelligent and well balanced, with overflowing optimism and fortitude, constitutes the ideal companion of the scientist.

"Will he direct himself to the opulent woman? It seems to us a very dangerous choice. Habituated to an easy life of luxury, of display, it would be a miracle if she did not contaminate her husband with her tastes; repeating the case of the illustrious English physicist Davy, who on having been married to a rich woman, stopped almost totally his brilliant career of investigator and consumed the best part of his life in feasts and receptions of the great world."

"It would be great fortune to meet with a rich and illustrious heiress who, abandoning the caprices and vanities of the sex, would consecrate her gold to the

service of science. Admirable women of this kind abound in other countries."

"Shall the scientist prefer the artistic wife or the writer? With honorable exceptions, such females constitute perturbation or eternal occasion of disgust for the cultivator of science. It is discouraging to recognize that as soon as she enjoys a virile talent and culture, the woman usually loses the charm of her modesty, acquires airs of dominance, and lives in perpetual exhibition of abilities and excellences. The woman is almost always a little theatrical but the writer and the artist is always in the scenery. And then they have such high and complicated tastes! Anyway, the opulent wife usually pays for what she wants. Little friend of books or reviews, she is interested only in jewelry and stores of fashion; but the literary woman sees with equal desire the windows of jewels and hats and the show cases of the book stores."

There is left then for our beginning scientist as a probable and suitable companion of glories and fatigues none but the industrious girl who is economical and endowed with mental and physical health, adorned with optimism and a good heart and with enough education to understand and encourage the husband and with the necessary passion to believe in him and to dream of the hour of triumph, that she considers sure. And he, instead of scolding and rebuffs, will find in the home a grateful atmosphere propitious for the germination and growth of ideas. . . ."

March of the Scientific Investigation

Observation: "One ought to clear the mind from the prejudices and images of others to make firm the purpose of seeing and judging by ourselves, as though the object was created expressly for the comfort and delight of our intellect. It is necessary finally, to reproduce as much as possible the state of mind—a mixture of surprise, emotion and vivid curiosity—through which the fortunate scientist went who discovered the fact considered by us, or who first attempted the problem."

"And this is closely associated with another rule praised constantly by the teachers of scientific investigation. It is not enough to examine, we must contemplate, impregnate ourselves with emotion and sympathy for the things observed, make them ours, both with the heart and by the intelligence. Only so will they deliver to us their secret. Like the lover who discovers daily in his beloved new perfections, the student who contemplates an object with delight ends by finding interesting details which have escaped others."

"We must work under the best possible conditions, taking advantage for the purpose of the more perfect analytical instruments and of the methods of study that deserve confidence. . . ."

Experimentation: "In many sciences experimentation surpasses in importance observation itself. It would be impossible to make discoveries in physics or in physiology, without imagining an original experiment, without subjecting the phenomenon studied to conditions more or less new. Morphology itself (histology, anatomy, embryology) for whose study mere observation seems to be enough, acquires every day a more experimental character. And to such a change of direction valuable conquests are due which never would have been achieved through the repeated method of the anatomical analysis of the static forms."

The directing hypothesis: "The facts observed, next it is important to fix their signification, that is, the relation that binds the new truth to the group of the postulates of science. In the presence of unusual phenomena the first move of the spirit is to imagine a hypothesis that will account for it and that places it under one of the known

laws. Experience will afterwards definitely pass upon the truth of the conception."

For the creation of the hypothesis he considers the following rules: *first*, that the hypothesis be required, *second*, that it be also contrastable or comparable, *third*, that it be easily imaginable, that is, translatable into physico-chemical language; *fourth*, that in escaping from occult properties and from metaphysical essences, it should tend toward solving the question of quality in problems of quantity; *fifth*, that it suggest investigations and controversies that bring us nearer to the good road, promoting new and more happy conceptions. Even though erroneous, the hypotheses can serve efficiently for progress if it be based on mere observations, and mark an original direction towards scientific thought. . . .

"It is difficult to dictate rules for imagining a hypothesis. The one who does not possess a certain intuition for causal linking or a guessing instinct to see the idea in the fact and the law in the phenomenon, will give a reasonable explanation very few times whatever his observing talent may be. . . ."

"*Proof:* The hypothesis, being imagined, it is necessary to submit it to the sanction of experience. For this we shall choose experiments or accurate observations, complete and conclusive. . ."

"If the hypothesis does not conform to the facts, it must be rejected without pity, and another explanation imagined, which is free from reproach. Let us impose upon ourselves severe auto-criticism, based on self suspicion. During the process of proof, we should use the same diligence in searching out the facts contrary to our hypothesis as those that can favor it. Let us avoid feeling an excessive love for our own ideas. They should find in us not a lawyer but a judge. . . ."

"When the work of confirmation throws but a feeble light, let us imagine new experiments and let us place ourselves in the best condition to evaluate the reaching of the hypotheses. In anatomy and physiology, for example, the impossibility of elucidating the structure or the function of a complex organ, occurs frequently. This results from the fact that we attack the problem from its more difficult side, pretending to solve it in man, or in the superior vertebrates. But if we go to embryos, or inferior animals, nature will show herself more ingenuous and less elusive, offering us almost the schematic plan of the structure and dynamism for which we looked and by which frequently our hypotheses will receive unexpected and definite confirmation. . . ."

Justification of the scientific communication: "Mr. Billings, wise librarian of Washington, oppressed by the task of classifying thousands of pamphlets in which almost the same facts or truths long known were brought forth in different styles, suggested to scientific writers the following rules: first, have something new to say; second, say it; third, stop as soon as it has been said; fourth, give to the publication appropriate title."

"Here is a suggestion which we do not believe useless in Spain, classical country of the hyperbole and the showy figure. In effect, the first thing that is necessary in treating of scientific subjects, when we are not trying to teach, is to have some observation or useful idea to communicate to others. Nothing is more ridiculous than the pretense of writing without being able to bring to the question a positive fact, with no other excuse than to show a feverish imagination, or to boast of pedantic erudition with data taken at second or third hand."

"Let us be sure, then, thanks to a careful bibliographic investigation, of the originality of the fact or idea that we desire to present, and let us keep from prematurely producing the fruit of our observation. When our thought

fluctuates between different conclusions and we do not have full assurance of having hit the target, it is a sign of having abandoned the laboratory too early."

Bibliography: "Before presenting our personal contribution to the theme of study, it is customary to sketch the history of the subject, either to mark the starting point or present a just tribute to the famous scientist who preceded us in opening the road of investigation. When at this point, either by love of conciseness, or by mere laziness, the beginning investigator tries to omit dates and quotations, let him consider that he might be paid in the same coin by others who intentionally ignore. . . ."

Justice and courtesy in the judgments: "In consigning the historical antecedents, we are frequently obliged to formulate judgments about the expositions of the work of others. It is unnecessary to give the warning that in such appreciations we ought to conduct ourselves not only with impartiality but by showing exquisite courtesy and agreeable and almost laudatory manners. Indulgent with the mistakes of the beginner, we should be respectful and modest before the lapses of the great scientific celebrities. Let us be always afraid that our observations represent superficiality or impatience or mirage of youthful enthusiasm before resolving ourselves to repudiate a fact or an interpretation commonly admitted; let us think maturely. And let us take into consideration when formulating our objections, that while among scientists we find noble and kind characters, there are also the irritable temperaments. . . ."

"When, unjustly attacked, we shall be forced to defend ourselves, let us do it bravely, using the sword, but with a blunt point, and adorned, as in the popular saying, with a bouquet of flowers."

"It is painful to recognize that in the majority of cases the contestants do not defend a doctrine but their own infallibility. It is the instinct of spiritual conservation that reacts. . . ."

Error of observation or of recognizing of a fact: "In general scientists discuss interpretations, not facts, because they suppose that the investigator, no matter how modest he be, is not capable of going into the analytical theory without sufficient preparation. It is precisely for this that those lapses are considered very grave, showing in those who commit them singular intellectual candor of methodological experience. Nevertheless, let us keep from being abusive when pointing out mistakes; let us be kind and let us remember that in moments of distraction or carelessness even the most sagacious scientist can commit them. Far from criticising crudely, let us excuse him with benevolence, pointing out that it is a matter of very hard observations, when the mistakes result frequently and almost unavoidably. Let us not impute the error to ignorance, but rather to the imperfection of technique used to the prejudice of the school where the criticised work was inspired. . . ."

Theoretical error: "Let us suppose that in interpreting the facts incorrectly, the author formulated an arbitrary hypothesis bearing on the facts without basis in observation. The critical pill should be gilded with phrases of this kind: 'Certainly the explanation proposed is a little bit venturesome, but on the other hand it is notably ingenious, suggests very elevated considerations and shows in its author a philosophical spirit of great reach. It is a great pity that in forming his conception he had not taken into consideration those facts that contradicted it formally! In any case the hypothesis is seductive and deserving of respectful discussion and examination!' "

Exposition of the methods: "It is important to note either at the beginning or at the end of the monograph the methods of investigation followed. The

author should not imitate those scientists who give as a reason that they are going to perfect it later and so reserve for themselves temporarily the monopoly of the technique employed restoring the custom of the chemists and mathematicians of the centuries past who, inspired with the puerile vanity of astonishing the people with the power of their penetration, reserved for themselves the details of the procedures that had given them the truth. Fortunately this sort of thing is disappearing from the field of science."

Conclusions: "Presented in clear form, concise and methodical, the deductions and observations, product of our researches, we should close the work, condensing the positive results in a number of short propositions."

Need of drawings: "If our studies refer to morphology, either macro- or microscopic, it will be necessary to illustrate the descriptions with figures copied as exactly as possible from nature. No matter how precise and detailed the description might be of the observed object, it will always be of inferior clearness to a good drawing. Especially since the graphic representation of the things observed guarantees the exactitude of the observation itself, and constitutes a precedent of inestimable value for those many who confirm our conclusions. With reason almost the same credit is given to-day to the one who draws an object faithfully for the first time as to the one who makes it known only through a more or less incomplete description."

The style: "Finally, the style of our work will be genuinely didactic; sober, simple, without affectation and without having any other preoccupation than order and clearness. The emphasis, declamation or hyperbole, should never figure in the merely scientific writings, if we do not wish to lose the confidence of the scientists, who might end by taking us for dreamers or poets incapable of reasoning or studying a question calmly. The scientific writer will aspire constantly to reflect the objective reality with the perfect serenity and honesty of a mirror, drawing with the word as the painter with the brush, and abandoning at last the pretension of an exquisite style and the fatuous boasting of philosophical depth. Let us not forget also the known saying of Boileau: 'That which is well conceived is clearly enunciated.' . . ."

Publication: "When the investigator enjoys a world-wide reputation he will be able to publish his scientific contribution in any review of the specialty, foreign or national. The scientists interested in the subject will not stop at the obstacle of language, on the contrary they will try to study to know the thought of the other, or look for editors to translate and publish it. Nevertheless, even to the most famous scientists it will be necessary to communicate his discoveries to the *Beitrage* or *Centralblatt* more read in Germany. As far as the beginner without any credit in the scientific world is concerned, he will act very wisely at the start by asking hospitality in the great foreign reviews, and writing or making translations of his works into French, English or German. Those who, inspiring themselves in a narrow and base patriotism, refuse to write in any other than local reviews and read little or not at all in scientific countries, are condemning themselves to be ignored even in their own country."

"It is then imperative for the future of the beginning investigator that the judgment of foreign scientific authorities be obtained. He will reflect maturely before submitting to them the first work; let him be well assured through constant bibliographic exploration, and even better, by the consultation of some famous specialists, of the reality and originality of the communicated facts. And let him not forget that the right to make mistakes is tolerated only in those who have already made their reputations."

EARLIER DEPRESSIONS

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"LIFE allows you four depressions," is a sentence concocted by an astute advertising man. Nowadays it stares at us from many a newspaper and magazine page. It compels attention. Suggesting uses of adversity, it is somehow vaguely reassuring. We read on: "The average investor's life spans eight to ten depressions. Three or four are gone before he knows what to do with them. Yet, if he is wise and able he may profit substantially from the remaining ones. During every major decline thousands of investors have established the foundations for future independence by the purchase of sound securities whose values rose with the recovery of American business."

But to the average investor the advertisement is after all only vaguely reassuring. He remembers with distinct nostalgia one economist's pronouncement, on the eve of the Wall Street debacle, that "stock prices are on a permanently high plateau." He recalls further the good money he sent after the bad in that first incredible decline. He can't forget those popular predictions of complete recovery by 1931. He recognizes now, as merely a Delphic wisecrack, the radio counselor's statement that "the depression will be over two months before we know it." In short, it dawns on even the most gullible that, although the rebirth of prosperity will, indeed, be a "blessed event," there is no Walter Winchell to set the date. As a matter of fact, the less stout of heart are badly worried over such headlines as "Germany Refuses to Pay" and the many species of magazine articles which nevertheless all belong to that ubiquitous genus, "When the Revolution Comes."

The trouble is that many of the investors who are hardest hit are really too young to remember any former depression; even the great majority of those who muddled through dull 1921 are already a little uncertain about what actually happened then; those who weathered the panic of 1907 have only a hazy recollection of its lessons, for their present discomfort is far more poignant than their ancient pains; the veterans who made fortunes out of the hard times of 1893 can marshal now only a few thin-ranked battalions. Leaderless, they have completely lost track of those earlier anxieties in a morass of present fears and a welter of apprehensions for the future. In short, even the most experienced lack perspective. In the quiet of their clubs they say to one another, "Yes, we've always come out of it before, and I suppose now may be the time to step into the market; but, confound it, John, things are different *this* depression. How do we know we'll *ever* come out of it? Look at Russia!"

Their forefathers for generations have had the same misgivings. Some of them wondered, with Lincoln, if the nation really could survive; others, with Washington, felt skeptical of the future of the colonies. Likewise, unknown Crô-Magnon leader, forgotten Basque chieftain, Sargon of Khorsabad, Hamilcar of Carthage, Nero of Rome, Caradoc of the Silures, Genghis of the Gobi, Lorenzo of Florence, Bonaparte of Corsica, Wilhelm of Prussia and Hoover of Palo Alto—all have realized fully the

story the past tells of the unending alternation of good and bad times. But they, even as you and I, have always felt that, regardless of the past, "Things are different *now*." Either "rich years will change only to become richer," or "hard times are only the harbingers of complete ruin," have run their thoughts, according to the particular circumstances under which they lived. In other words, whether ancient, medieval or modern, the historians, philosophers, courtesans, priests, soldiers, medicine-men, artists, pugilists, college presidents, tycoons, economists and politicians have all agreed that the history of the past is the prophecy of the future, but they have never failed to reconcile themselves to the thought that they, their affairs and their times are somehow exceptions.

Yes, the historian knows that man has experienced countless earlier depressions, and that at least those which have occurred during the periods of written history have been generally misunderstood. But the geologist, who, with Hutton, looks down the vista of the past to see "no vestige of a beginning" and scans the illimitable horizon of the future to discern "no prospect of an end," is alone fully cognizant of the true measure of antiquity which must be allotted to earlier depressions. Woman-like, Old Mother Earth keeps some of her secrets from even the geologist's ceaseless pryings. But he at least knows that earlier depressions are countless, that our globe enjoyed them even prior to the advent of life, and that life itself has waxed strong in ages of adversity and fallen into sorry ways in periods of plenty.

"The everlasting hills" is a phrase as irritating to the geologist as "all men are created equal" is to the sociologist. It is as poorly conceived as that fictitious "permanently high plateau" of stock prices. Tennyson tried to correct its erroneous impression of stability by writing, "The hills are shadows, and they flow from form to form." The geologist can only reiterate that mountains of solid rock almost, if not quite, as high as the peak of the 1929 market have been elevated to haughty alpine grandeur only to be reduced to the ignominity of sea-level by the various agents of denudation, which are only slightly inferior to a bear operator in their ruthlessness.

The ocean has flooded the land not once but scores of times; and each inundation has written the record of its existence in the sedimentary deposits which it left behind.

> There rolls the deep where grew the tree,
> O Earth, what changes hast thou seen!
> There, where the long street roars hath been,
> The stillness of the central sea.

This is not only poetry but sound geology. The areas of Riverside Drive, Michigan Boulevard, Unter den Linden, the Strand and the Champs Elysée have all been beneath the "central sea" at repeated intervals. Even now Great Britain is sinking at a rate which is sufficiently rapid to effect nearly complete submergence within the next 40,000 years. Picture if you can a geographical map of Europe without the identification tag of the British Isles! Imagine the consternation of the Englishman 400 centuries removed who finds that at last the "waves rule Britannia" instead of the traditional converse!

Yes, even the continents have had their ups and downs, and, of course, their areas have changed remarkably throughout the past. They have presented bold, swashbuckling outlines when they stood high, but they have made sorry, attenuated showings during their periods of depression. Old Mother Earth has indeed suffered many vicissitudes. Her facial expression is one of great mobility. Although the changes

are ordinarily too slight to be noted by the casual observer, the geologist knows that during the long geologic past her face has been wrinkled where now it is smooth and unmarked where now it is deeply furrowed. As amanuenses to the "Old Lady" the geologists also know that she still entertains young ideas. She has surreptitiously lifted her face time and again. But the parable from the past is more clearly understood and more definitely encouraging when we remember that the earth has not only risen above her earlier depressions, but she has generally risen higher, rejuvenated and youthful after each succeeding deluge.

Protean Depression's innumerable offspring always include such relatively unimportant financially spoilt children as broken Mississippi Bubbles—in this present case Kreuger and Insull varieties—which are remarkedly similar to such localized earth catastrophes as the collapse of volcanic peaks, which after all are more dangerous as lofty cones than as the resulting yawning calderas. But neither physical nor financial collapses are unmixed evils. The calderas which scar Mother Earth's broad weather-beaten face lend it character. The open financial wounds of the trusting public likewise soon give way to investment scars, which long remain to warn, even though they go unheeded. And who would insist that ancient Mount Mazama could have been in all its symmetry and towering height more inspiring than its incredible scar, the caldera of Crater Lake?

The record of earlier depressions is, of course, only in part a physical story. Even more pertinent comparisons may be drawn with the panics which life itself has encountered and survived Anteus-like, with strength redoubled.

If all geologic time is taken as 2,000,000,000 years and is represented on a clock dial as one hour, then 33 minutes of that hour elapse before the age of invertebrate animals is well under way. Even the beginning of the age of reptiles and the dominance of dinosaurs occurs only nine minutes before the minute hand reaches twelve. More surprising still is the fact that mammals, the dominant life of the present, have been the ruling animals of only the last paltry two and a half minutes of the hour. And man, commonly thought to have been present for 1,000,000 to 2,000,000 years, has only occupied the center of the stage a breathless two or three split seconds. In fact, man is such a newcomer that he has existed only while our geological clock has been striking the hour. But in spite of the fact that "depressions" occurred long before the advent of life, it is the effect of "hard times" upon organisms which particularly concerns man, the rankest of the untried *nouveau riche* among the animals, many of which for ages have lived in intimate association with man's relatively new acquaintance, Immortal Depression.

During the countless "depressions" which the world has been "allowed" in all those millions of years since the first successful organic synthesis, there has been an upward trending, though ragged, curve in the graph of the life complexity. In times of stress the weak organisms have died out, but the strong have always emerged from the troughs of trouble more powerful than ever. Modified to fit the changing environment, they have been ready to take advantage of the return of "good times."

The trilobites, marine crustaceans of the Paleozoic, constituted the Vanderbilts, Harrimans and Potter Palmers of the early part of that distant era. Incredible as it may seem, they were the first families then; and in their time there was no living thing to dispute their prominence, at least in the matter of intelligence. Nevertheless, in their

own life history they tell the old but ever recurrent story of the survival of the simple and the destruction of the specialized. The ornate members of the group (for even the intelligent have never completely resisted the urge of megalomania), like over-expanded individuals, families or industries (and universities as well), flourished in times of plenty, but they became extinct long before their lowly, generalized and conservative cousins had departed from the scene.

Primitive fish, living under the difficult conditions of elevating lands and dwindling, shifting streams characteristic of late Devonian times, were consequently greatly diminished in numbers. But a few ganoid types, with the true spirit of pioneers, used their fringed fins to painfully crawl from the desiccating ancestral pools to other less stagnant ones. These first air-breathing, partially land-living vertebrates not only gave rise to the amphibians—they originated a Paleozoic parable to the effect that, then as now, animals or industries which, instead of bowing to "hard times," use what resources they have to meet the changing situations are likely to be rewarded handsomely with the return of "prosperity."

The great refrigeration at the close of the Paleozoic era, with the attendant wide-spread glaciation, and the nearly world-wide crustal unrest, combined to make a time of great physical revolution, which was attended by organic disturbances of the most far-reaching sort. In fact, the destruction of life at this time was so great that the early geologists thought that all living things had been blotted from the face of the earth, although we now know that, severe as that "depression" was, a few strong, generalized types survived it. Their descendants repopulated the earth with new and more vigorous inhabitants.

Alcide d'Orbigny, as late as 1848, in studying the rocks of Europe came to the conclusion that the life of the earth had been annihilated not only at the close of the Paleozoic, but *twenty-seven times in succession*, and that twenty-seven distinct creations had repeopled the entire globe with new plants and animals, each new creation resulting in life more advanced than that which had just been blotted out. It is now known certainly that the thread of life, although stretched to extreme tenuity at many times, has never been broken. Life has indeed gone into its nadir even more often than the mere twenty-seven "geologic depression" times that d'Orbigny knew, but always it has returned to an ever more glorious zenith on the crests of new waves of successive early periods of prosperity.

The Mesozoic reptiles were megalomaniacs of the most confirmed sort. They were the masters of all the important habitats. The dinosaurs ruled the land, marine reptiles invaded and conquered the sea, and the "flying dragons," or pterodactyls, were lords of the air. But scurrying underfoot of the giant dinosaurs were a few mouse-like primitive mammals. They were subservient indeed to the gigantic masters of the moment, who, as is characteristic of the great (and especially the near-great), probably were totally unaware of the mammal's presence. But these small creatures, like some apparently insignificant individuals and many unpromising infant industries, had great potentialities. They proved their mettle at the close of the Mesozoic, when the earth went through another one of her really great "depressions."

This was, indeed, a time of revolution and of the "reddest" sort, for the reptiles, like Russian royalists, were nearly blotted out, and they have never again been particularly dominant. But the

small mammals weathered the hard times successfully. Out of their crude beginnings have come the greatly diversified and ruling mammalian types of to-day. They were one group which was not over-expanded at the time when opportune depression hit them. In effect, they sold the market short and made their fortune in the steady decline of reptilian values. The roots of that great modern spreading tree of mammalian types were firmly anchored in the very depression which was too drastic for the optimistic dinosaurs who, to the final crash, continued bullish on "Brawn not Brains, Inc."

Yes, the earth has enjoyed countless "depressions," the most wide-spread of these, paradoxically enough, being at times of great mountain building. And although some of the results have been so far-reaching that all life has seemed to have been blotted out, a few of the simple, sturdy stocks in actuality have always weathered the storm to build new and more glamorous family careers during the following period of inevitable world recovery. And for to-day's timid soul the most encouraging feature is this—the new forms of life have always been more advanced than those whose places depressions made vacant.

The parables from out of the past are clear: All "hard times" are really "good times." Fortunes, families, mountain ranges and even continents rise out of "depressions"; all hard times are inevitably followed by "good times," which, in effect, are "bad times," inasmuch as in them family fortunes, individual initiative, national ideals and even lofty mountains are so weakened or reduced that they are likely to be completely destroyed or at least radically altered by the time the next "depression" is well under way.

Yes, Old Mother Earth has experienced many a depression. She is "enjoying" one now. But mother-like, she knows that mankind, her one unnatural offspring, is contrary enough to cry for the heady wine of plenty. And like the indulgent mother she is, once again she is preparing that universal pacifier—prosperity. It's an old story for her. She did it many times for her less articulate children before mankind was born.

THE RELIGIOUS AFFILIATIONS OF AMERICAN LEADERS

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DISCUSSIONS of the status of religion frequently lead to more heat than light. Truth comes hard in most fields but especially so in the realms of religion.

Some insight into the place of the church in the American social fabric can be gained from that hardy biennial of information—"Who's Who in America."[1] An analysis of the nearly 30,000 write-ups given in the 1930–31 edition, together with studies covering about two thirds of the names in the 1910–11 volume, shows that the religious affiliations of these American leaders are closely interrelated with their professions and occupations. Proportionately only half as many botanists and astronomers report any church connections as do educators or social workers. Moreover, in relation to the known distribution of the country's church membership, a disproportionately large number of people in "Who's Who" claim to be Unitarians, Reformed, Universalists, Episcopalians, Congregationalists, Quakers, or Presbyterians, while comparatively few say they are Methodists, Baptists, Disciples of Christ, Lutherans or Roman Catholics. Jews, too, appear very infrequently.

Certain types of religious beliefs are associated with particular lines of endeavor. Congregationalists and Unitarians, with their liberal tenets, especially excel as natural scientists, while Episcopalians lead among army and navy officers, and among architects and engineers.

[1] "Who's Who in America, A Biographical Dictionary of Notable Living Men and Women of the United States." Edited by Albert Nelson Marquis, Chicago. Vol. 6 and Vol. 16.

As most people are aware, "Who's Who" aims to include, as nearly as possible, brief life-sketches of the most notable living Americans in all parts of the world. The standards of admission divide the eligible into two classes. One comprises persons selected because of special prominence in various lines of endeavor, such as science, education, business and the arts. The other includes individuals chosen because of their official position and embraces all members of the Cabinet and of Congress, all United States judges and governors of states, all officers of the army above the rank of colonel and officers of the navy above the rank of captain, and all American ambassadors and ministers, as well as accredited foreign ambassadors and ministers residing in this country. In addition this arbitrary group includes American authors of books possessing more than "ephemeral" value, the bishops and chief ecclesiastics of the larger religious denominations and the heads of the larger universities and colleges and of certain well-known philanthropic, educational and scientific organizations.

There are some people who question the validity of any study based upon "Who's Who," on the ground that the list omits certain outstanding leaders and includes a number of third-rate ones. This does not, however, invalidate the present use of the volume. The main purpose of this inquiry was to ascertain the denominational affiliations of different classes of American leaders. For this purpose the individuals in "Who's Who" seem to constitute an adequate sample. There is no doubt that the volume contains many of the important

figures in contemporary American civilization. Glancing through the 1930–31 edition one runs across such outstanding personalities as Jane Addams, Nicholas Murray Butler, S. Parkes Cadman, Clarence Darrow, Mischa Elman, Simon Flexner, Cass Gilbert, Herbert Hoover, J. Pierpont Morgan and General John J. Pershing.

What proportion of the leaders in "Who's Who" claim to have any church connection? This question can be answered accurately because each candidate was asked among other things to report upon "religious denomination—if any." The returns show that out of the 29,623 write-ups analyzed in the 1930–31 edition, 16,629, or 56 per cent., reported denominational connection. This proportion is almost exactly the same as the average for the population as a whole. According to the 1926 Federal "Census of Religious Bodies," the number of persons over thirteen years of age listed on the membership rolls of the churches is equivalent to 55 per cent. of the entire population above that age. Apparently, American leaders do not differ from the rank and file in the extent of their church allegiance.

The relative number of individuals in "Who's Who" reporting a church affiliation has been growing very rapidly. An analysis of all the names from A to My in the 1910–11 edition of the volume shows that only 2,844, or 25 per cent., of the 11,355 names included said that they had a church connection, compared with 56 per cent. to-day. This increase is so rapid that the question arose whether during the period the method of obtaining the religious denomination of the candidate had been fundamentally altered, but correspondence with Mr. Albert Nelson Marquis, the editor of "Who's Who in America" revealed that it had not. These data would seem to indicate that during the last generation a church connection was looked upon with increasing favor.

In a further effort to compare the religious affiliations of the older and the younger generations of American leaders, several professional and occupational groups from the 1930–31 edition were analyzed by age periods to find out if younger men gave a denominational preference with less frequency than older people. Surprisingly enough, the results show that the percentage of individuals reporting a religious connection decreases as their age increases. The very old people record a denominational affiliation less frequently than any other age group. At least, this generalization holds for social and natural scientists, doctors, agriculturalists, and bankers and business men—the five groups analyzed in this fashion. It is not easy to account for this tendency, but it should be borne in mind that the rising generation of Americans are not as yet adequately represented in "Who's Who."

Almost as surprising as the large proportion of persons that claim a church connection is the small number who state that they are unbelievers. Out of the 29,623 names only seventeen took occasion to classify themselves in black and white as infidels, atheists, free thinkers or agnostics. In short, fewer than one of 1,700 leaders put themselves on record as being distinctly anti-religious. Ten of these militant non-conformists are writers; three are natural scientists; two are doctors; one is an artist and one is a mechanical engineer. In this connection it is interesting to note that of the thirty-two Presidents of the United States only three—Thomas Jefferson, Rutherford B. Hayes and Abraham Lincoln—did not claim a definite church connection.

Religion and Occupation

The data from "Who's Who" also tend to show that the more creative or mechanistic is a person's job the less the likelihood that he will be actively related

to any denomination. Among actors, painters and sculptors only 23 per cent. claim a church connection, while among army and navy officers this proportion is 35 per cent. and among natural scientists 37 per cent. For editors and authors the ratio is 40 per cent., for social scientists 42, for doctors 50 and for architects and engineers 51 per cent. All other groups report higher proportions. Among the pillars of society—the politicians and diplomats, the judges and lawyers, the agriculturalists and the bankers and business men—from 54 to 61 per cent. report a church affiliation. Educators and social workers claim even higher percentages, with 63 and 64 per cent. respectively, but naturally religious workers show the highest returns, with 100 per cent. giving church connections.

These figures raise the question whether the religious affiliation claimed by the "Who's Who" fraternity is not, in considerable part, a matter of social pressure. Certainly a professor in a denominational college has a greater incentive to claim a church relationship than has a sculptor, an army officer or a chemist.

Because of the peculiar influence of natural scientists in the modern world, it is interesting to contrast returns from different groups of scientific men separately. Among seven classes studied, astronomers show the smallest proportions, with only twenty-seven out of eighty-five, or 32 per cent., claiming a denominational relationship. Zoologists and biologists, including botanists and naturalists, report 36 per cent., while chemists show 37, physicists 40 and geologists 42. At the top of the list are mathematicians, with 52 per cent. giving a church connection. These figures support the belief that even the religious attitudes of scientific men are influenced by the particular type of research upon which they are engaged.

Denominational Affiliation

A person in "Who's Who" is as likely to report a church connection as is the average man on the street, but his denominational connection is usually quite

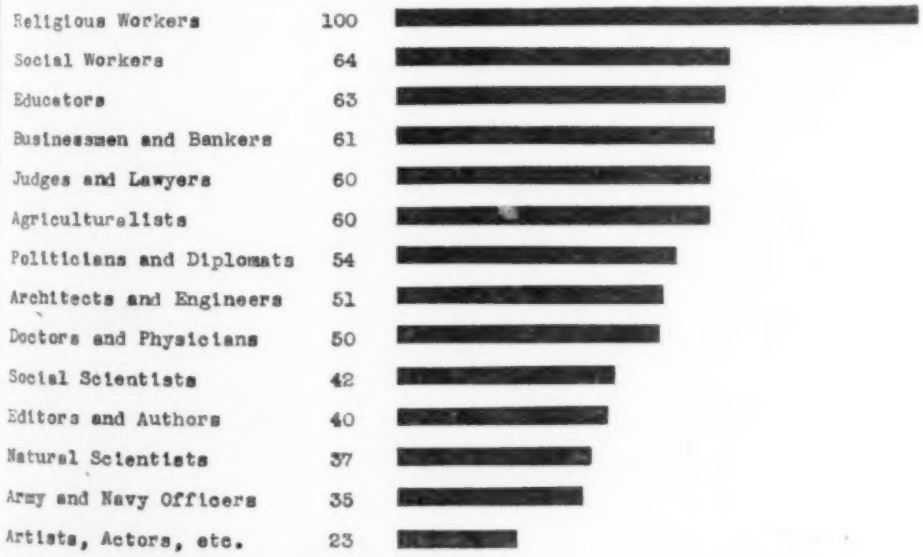

CHART I

PER CENT. OF PERSONS IN "WHO'S WHO" REPORTING CHURCH AFFILIATIONS BY OCCUPATIONAL GROUPS.

different. The great majority of leaders who report any church allegiance claim to be related to a handful of denominational groups. On the average, Episcopalians account for twenty-two out of every hundred; Presbyterians for twenty, Methodists for fourteen; Congregationalists for eleven and Baptists for nine. In other words, more than three quarters of the people who mention any denomination say they are affiliated with one of these five groups. Unitarians comprise 5.1 per cent. of the total and Roman Catholics only 4.5 while Lutherans report 2.4, Disciples of Christ 2.1 and Jews 1.3 per cent. All other denominations show smaller proportions.

For comparative purposes all the names from A to My in the 1910–11 "Who's Who" were also classified, to learn how the denominational composition of these leaders has been changing. The results, which are presented in Chart II, indicate that Unitarians and Universalists, and especially Roman Catholics, have been declining in relative numerical importance, while other denominational groups, particularly Congregationalists, Disciples of Christ and Christian Scientists have increased comparatively rapidly.

Denominational Representation in "Who's Who" and the Population

The present representation in "Who's Who" of the different religious families does not at all correspond with the denominational distribution of church membership in the United States. This conclusion was reached through a de-

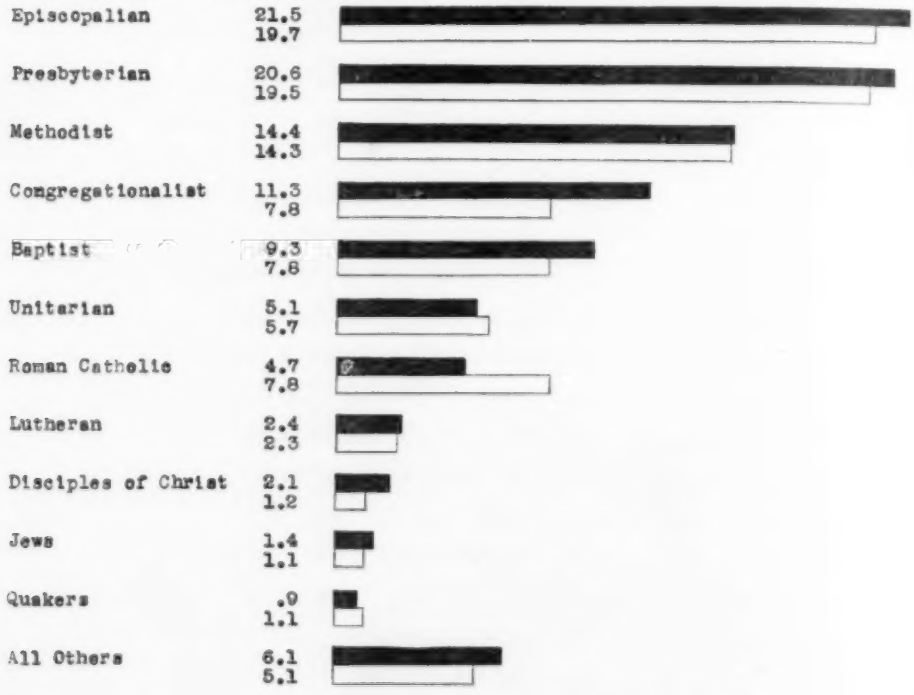

CHART II

CHURCH CONNECTION OF PERSONS IN "WHO'S WHO" REPORTING CHURCH AFFILIATIONS.

tailed comparison of the relative numbers of church members in "Who's Who" and in the population as a whole. Using the data secured by the 1926 Federal religious census, the total number of church members over thirteen years of age was worked out for all the different white Christian denominations.[2] Negro bodies were entirely omitted, because the individuals in "Who's Who" are almost exclusively white. Jews, too, were left out of account, because this faith does not employ membership figures that are comparable with those of Christian Churches. On this basis the denominational representation in "Who's Who" in proportion to general church membership is shown on Chart III.

This comparison, which necessarily excludes Jews and which is further limited to thirteen church bodies having at least 100 representatives in "Who's Who," shows that the denominations concerned fall into four groups. At the top of the list are the Unitarians who are so far ahead of all the rest that they constitute a class by themselves. There are actually thirty-two times as many Unitarian representatives in "Who's Who" as the numerical size of the denomination would lead one to expect. The number is so large that the question arises whether a certain number of individuals have not classed themselves as Unitarians who have no active relation with the denomination. A candidate who was not associated with any church but who felt that a denominational connection was advantageous might well classify himself as a Unitarian both because this church is liberal theologically and because it enjoys social status.

The second class comprises a group of half a dozen bodies that have from 6.5 to 3.1 times as many representatives as might have been anticipated from their membership strength. In this group are the Reformed, Universalist, Episcopalian, Congregational, Quaker and Presbyterian churches. These denominations, together with the Unitarians, enjoy a preferred status: twenty-two of the twenty-nine American Presidents claiming church connections have been affiliated with these bodies.

The next class includes, in addition to Christian Scientists, such old-line

[2] C. Luther Fry, "The U. S. Looks at Its Churches." New York; Institute of Social and Religious Research. 1929.

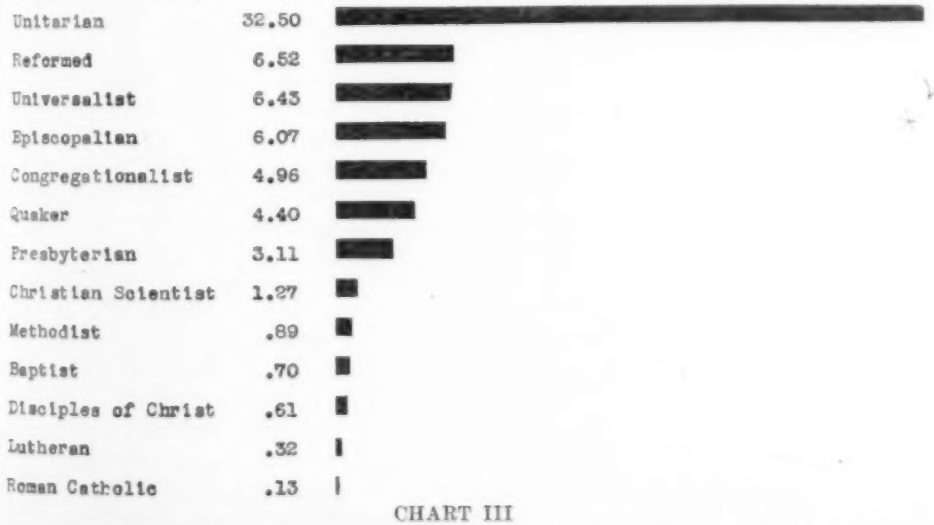

CHART III

DENOMINATIONAL REPRESENTATION IN "WHO'S WHO" IN PROPORTION TO GENERAL CHURCH MEMBERSHIP.

Protestant denominations as the Methodists, Baptists and Disciples of Christ. Among this group the actual representation in "Who's Who" ranges from 1.27 to 0.61 times the expected number. Only six presidents were members of these denominations.

At the bottom of the list are Lutherans and Roman Catholics, who report, respectively, 0.32 and 0.13 per cent. of their membership quotas.

The proportionate representation of the Jews can also be ascertained, but through a somewhat different method. The last religious census found 4,081,000 persons of Jewish faith living in communities in which local synagogues are situated. Even assuming that this figure represents the total Jewish population of the country, it means that at least 3.57 per cent. of the inhabitants of the United States are Jews. On this basis one would expect the same proportion of Jews to appear in "Who's Who," but as a matter of fact only 218, or 0.74 per cent., of the names analyzed claimed to be Jews.

As a further check upon the Jews a special study was undertaken of the people who did not report religious connection in "Who's Who," even though they are listed as Jews in the "American Jewish Yearbook" or "Who's Who in American Jewry."[3] It was found that there were 432 such persons, compared with only 218 who stated they were Jews. In other words, not more than a third of the individuals of Hebrew extraction claimed to be connected with a Jewish synagogue. Out of sixteen architects and engineers who are racially Jewish not one claimed any religious affiliation, while only nine out of fifty-five scientific men falling into this category classed themselves as Jews. Of course, it may be that Jewish leaders have broken with their religion to a greater extent than is the case among Christians, but it is also true that certain individuals may hesitate to classify themselves as Jews because such an admission would be considered a social liability. At all events those professing the Jewish faith are distinctly underrepresented in "Who's Who."

It is scarcely a matter of chance that the denominations which are least represented in "Who's Who" are the Jews, Roman Catholics and Lutherans, that have comparatively large numbers of foreign-born adherents. There has never been a President of the United States who was a member of any of these bodies.

Denominational Representation by Occupation

It has often been claimed that what a person says he believes on Sunday has no relation to his occupational activities during the week, but is this belief well founded? Certainly the information assembled by this inquiry leads to the conclusion that there is a definite relationship between a man's profession and his profession of faith. The results are summarized in the accompanying list. As might have been expected, no Quakers are found among army and navy officers, and no Christian Scientists among the doctors and physicians.

The Puritanical position which holds that the theater is sinful is reflected in the fact that Baptists and Methodists make their poorest showing among actors, sculptors, etc., while Roman Catholics, Lutherans and Episcopalians, who have long been patrons of the theater, rank high among actors.

The denominations that report comparatively large numbers of politicians are the bigger bodies that have strong voting strength—the Baptists, Meth-

[3] "American Jewish Yearbook," Vol. 33, 5692 (1930–31) Philadelphia, Jewish Publication Society of America; "Who's Who in American Jewry," 1928, New York, The Jewish Biographical Bureau, Inc.

Makes best showing among	Denomination	Makes poorest showing among
Educators Politicians	Baptists	Architects, engineers Artists, actors, etc.
Actors, artists, etc. Army and Navy officers	Christian Scientists	Doctors (None) Social workers (None)
Natural scientists Social scientists	Congregationalists	Doctors and physicians Army and Navy officers
Agriculturalists Social scientists	Disciples of Christ	Actors, artists, etc. Army and Navy officers
Army and Navy officers Architects and engineers	Episcopalians	Natural scientists Agriculturalists
Actors, artists, etc. Politicians	Lutherans	Judges, lawyers, etc. Army and Navy officers
Educators Politicians	Methodists	Architects and engineers Actors, artists, etc.
Business men, bankers Judges, lawyers	Presbyterians	Army and Navy officers Actors, artists, etc.
Agriculturalists Social scientists	Quakers	Judges, lawyers (None) Army and Navy officers (None)
Editors, authors Agriculturalists	Reformed	Social workers Natural scientists
Actors, artists, etc. Politicians	Roman Catholics	Agriculturalists Social scientists
Natural scientists Social workers	Unitarians	Politicians Army and Navy officers
Editors, authors Judges, lawyers	Universalists	Social workers Agriculturalists

odists, Lutherans and Roman Catholics. Denominations like the Roman Catholics, Episcopalians and Universalists, that are largely concentrated in cities, naturally claim relatively few followers among the agriculturalists.

Some denominations show much greater occupational versatility than others. Presbyterians, for example, are represented in each field almost equally well. Relatively they are most numerous as bankers and business men, but with the exception of the arts—acting, painting, sculpture, etc.—they make much the same showing among the other occupational and professional groups.

Two denominations that are distinctly liberal in theology—the Congregationalists and the Unitarians—rank especially high among natural scientists, while the Roman Catholic Church, with its rigid set of beliefs, is very poorly represented.

Checking the Findings

The findings for the natural scientists afford the opportunity of testing the significance of the data presented in this study. Some months ago Dr. Harvey

C. Lehman and Dr. Paul A. Witty published an article on "Scientific Eminence and Church Membership"[4] which employed a distinctly different method from the one adopted in this inquiry. Instead of relying upon the names that happen to appear in "Who's Who" these investigators hand-picked their candidates. Using the 1927 edition of "American Men of Science," the biographical dictionary edited by Professor J. McKeen Cattell, they selected from among the 13,500 names listed there the 1,423 that according to carefully worked out tests have achieved notable success in their particular fields. They then looked up each one of these individuals in "Who's Who" in order to find his religious affiliation. During this process a sixth of the names had to be eliminated because they were not listed in "Who's Who." This left 1,189 eminent scientific men whose church connections, if any, could be ascertained. The advantage of this method lies in the fact that only unusually distinguished natural scientists were included. No person was counted merely because he happened to hold an official position. The "stuffed shirts" were entirely eliminated.

How do the results of that inquiry compare with our own? Lehman and Witty found that only 25 per cent. of eminent scientific men claimed any church connection, compared with 37 per cent. of the natural scientists in "Who's Who." Obviously, highly distinguished scientific men report a church connection even less frequently than the findings of the present inquiry would indicate. With this exception the two sets of findings agree very closely.

Comparative figures showing the proportionate representation of scientific men among the different denominational groups are given in the following table:

Denominations	Lehman and Witty	Fry
Unitarians	81.40	64.38
Congregationalists	9.31	9.55
Friends (Quakers)	6.60	7.20
Episcopalians	5.70	3.55
Presbyterians	3.05	3.20
Methodists	.44	.89
Disciples of Christ	.29	.41
Baptists	.24	.49
Lutherans	.20	.25
Roman Catholics	.05	.04

This comparison reveals that Lehman and Witty found 81 times as many eminent scientists classed themselves as Unitarians as might have been anticipated from the membership strength of that denomination, while our "Who's Who" analysis shows 64 times the expected number. For most denominations the correspondence between the two series of findings is extraordinarily close.

In general both sets of figures tell the same story—liberal Congregationalists and Unitarians at the top and conservative Lutherans and Roman Catholics at the bottom. Moreover, the most striking differences between the two results are owing to a correction adopted in this study that was not employed by Lehman and Witty. As every one knows, certain denominations, notably the Methodist and the Baptist, have a very large number of Negro members. It hardly seemed fair to include these members of colored bodies when computing the proportionate representations of the two denominations. This, therefore, is the reason that our computations give the Methodists a rating of 0.89 and the Baptists of 0.49 when the comparable figures of Lehman and Witty are only 0.44 and 0.24, respectively.

[4] "Scientific Eminence and Church Membership," *The Scientific Monthly*, December, 1931, p. 544.

The materials collected by this study tend to prove not only that a man's religion is closely associated with his occupation or profession but also to support the general thesis developed by André Siegfried in "America Comes of Age"[5] that the dominant tradition in this country is distinctly Anglo-Saxon and Protestant.

[5] André Siefried, "America Comes of Age." New York; Harcourt, Brace and Company, 1927.

DETAILED DENOMINATIONAL REPRESENTATION IN "WHO'S WHO" IN PROPORTION TO GENERAL CHURCH MEMBERSHIP*

Occupation	Episcopalian	Presbyterian	Methodist	Congregationalists	Baptist	Unitarian	Roman Catholic	Lutheran	Disciples of Christ	Quakers	Reformed	Universalist	Christian Scientist
Religious workers	3.69	3.13	.98	3.64	1.14	14.38	.21	.65	.73	1.20	1.41	7.86	1.02
Judges, lawyers	7.16	3.40	.90	4.04	.61	36.25	.14	.17	.76	2.00	.49	7.14	1.00
Doctors, physicians	8.09	3.29	.72	3.43	.60	41.25	.10	.25	.44	2.40	.29	5.71	—
Educators	3.77	3.20	1.20	7.00	.84	30.00	.04	.26	.70	6.80	.59	4.29	.52
Editors, authors	7.76	2.61	.68	4.78	.49	39.38	.15	.20	.50	4.80	.99	15.71	2.98
Architects, engineers	9.59	2.73	.49	5.70	.30	60.63	.09	.20	.23	6.40	.15	3.57	.85
Business men, bankers	8.09	3.66	.68	4.26	.47	30.00	.13	.20	.47	5.20	.43	4.29	1.63
Actors, artists, etc.	9.13	1.77	.44	3.57	.20	52.50	.23	.66	.15	6.40	.34	2.14	7.25
Politicians, diplomats	5.96	2.95	1.13	3.43	.80	15.00	.19	.45	.85	3.20	.38	6.43	.72
Social workers	4.24	2.70	1.12	7.26	.63	63.12	.05	.24	.20	9.60	—	—	—
Army & Navy officers	14.54	2.20	.50	2.04	.41	7.50	.18	.16	—	—	.44	4.29	4.33
Natural scientists	3.55	3.20	.89	9.55	.49	64.38	.04	.25	.41	7.20	—	5.71	.89
Social scientists	5.00	2.76	1.11	8.52	.48	36.88	.03	.20	.96	10.40	.48	5.00	.69
Agricultural group	2.68	3.17	1.05	8.04	.52	35.00	.03	.25	1.26	2.40	.79	—	3.42
All others	8.91	2.51	.59	2.74	.56	45.63	.11	.30	.64	2.40	1.84	14.29	1.06
Total	**6.07**	**3.11**	**.89**	**4.96**	**.70**	**32.50**	**.13**	**.32**	**.61**	**4.40**	**6.52**	**6.43**	**1.27**

* This comparison is limited to the Christian denominations having more than 100 representatives in "Who's Who in America."

CAPTAIN JOHN SMITH'S MAP OF VIRGINIA

THE "NOBLE SAVAGE"

By Dr. ELSIE MURRAY
ITHACA, N. Y.

THE naïve faith in the "natural man" which ran like wildfire through the eighteenth century has baffled the curious of more than one generation. The strange obsession that, uncorrupted by kings, clothes, parliaments, printing or ceramics, man was or would be a wholly admirable creature must somewhere have had a nucleus of fact. No mere academic whimsey (Van Loon and Cabell to the contrary) ever possessed such potency. Who launched this myth of the "noble savage"—destined to intrigue the wits of savants and talemongers for two centuries, and ultimately change the face of Europe?

Not long since, as I thumbed the stained and tattered pages of a small calf-bound copy of John Smith's "True Travels," a sudden light broke in on the enigma. The little volume provides rough going for the twentieth century reader. A truer cross between "Ulysses" and a schoolboy version of the "Aeneid" it would be difficult to figure. Brave the Joycean intricacies of its style, however, and one fact rises clear above the wordy welter. The *Sasquesahanoughs*, vestiges of whose culture and long occupation of the Susquehanna have lately been retrieved near Safe Harbor, were the originals of the "noble savage"; and Captain John Smith of Jamestown the artist who first limned their portrait, in the year 1609!

"Such great and well-proportioned men," writes Smith, "are seldom seene; for they seemed like Giants to the English, yea and to their neighbors, yet seemed of an honest and simple disposition." As for their speech, it is "the strangest in all these countries, for their language it may well beseeme their proportions, sounding from them as a voyce from a vault." The few phonetic samples submitted, notably *kekataoughtassapooesksku*, the numeral for ninety. and *necuttwevnquaough*, the slightly less appalling equivalent for a thousand, would appear to furnish ample warrant for the last reflection.

The garb and adornment of these natives set even the traveled Elizabethan gaping. For, unlike the subjects of Powhatan, they were clothed in "the skinnes of Beares and Woolves, from which the eares, nose, teeth, and paws still dangled." One had the head of a wolf hanging on a chain for a jewel, another a string of white beads weighing six or seven pounds, a third a green and yellow snake hanging from a perforated ear. Yet more astounding, in size and contour, were the tobacco-pipes they carried. Three quarters of a yard long and more, Smith describes them, "prettily carved with a Birde or a Deere, or some such devise at the great ende, sufficient to beat out one's braines!"

A singular item in the picture arrests the attention of the reader. Smith, in common with many of the early explorers, reports the epidermis of the native as white at birth. In the adult, however, it was customarily decorated with stripes, or tattooed totem animals, or stained cinnamon brown by a decoction of roots and oils, for protection against the attacks of insects or climatic change. Regrettably, the recipe for the cosmetic by which the latter object was effected is inadequately recorded. It might have made the fortune of some latter-day chemist.

Penetrate further into the "General

Historie of Virginia" and conviction grows. Here was a source-book of inestimable riches—for all its execrable English. The golden-agers, the back-to-naturists, and fanatics of equality—the Rousseaus, Swifts, Defoes, Montesquieus of many generations—must have dug pertinent facts and fancies from its pages. Even the youthful Milton may have found treasure-trove in the "True Travels." The revels of "Comus" find their prototype in the fanciful sketch of Pocahontas' *mascarado* with her maidens. The Lady of the Masque herself, chaste and imperturbable, may derive, paradoxically, from the Indian princess, "Powhatan's dearest daughter," whom "darkest night could not affright, nor coming through the irksome wood."

The converse is, of course, as credible. Smith, the old rascal—the original Trader Horn of the Americas—was taxed even in his own day with having "writ too much and done too little." Out and out Elizabethan, with an equal verve for phantasy and fighting, he may well have warped his tale to a literary model. The account of the *mascarado* above referred to, savoring now of Malory and the "Mort d'Arthure," and again, threatening to out-Bottom Bottom with its "excellent ill varietie," affords ample warrant for the last assumption. The finale of the *mascarado*, with Pocahontas' "nymphs," clad in green leaves and otters' skins, "crowding, pressing and hanging about, crying 'Love you not me, love you not me?'" is a veritable travesty of Parsifal's temptation, with the circle of flower-maidens closing in seductively about the hero.

So much for romance! The captain's account of the sixty "giant-like" Susquehannocks who came down to greet him—sun-worshippers, disposed to bend the knee before his resplendent doublet and plumed headgear—is of course on an utterly different footing. It is possible, to be sure, that the mental yardstick on which Smith laid off the length of the carved stone pipes of his visitors, the leg-span and stature of their chiefs and *werowances*, may have lacked precision. On many counts, however, his description checks with data from quite independent sources.

Sober seventeenth century narratives of Swedish missionaries on the Delaware, of Jesuit Fathers marooned among the Hurons on the St. Lawrence, corroborate the Captain's jottings. Even young Alsop, who turned his back on Puritan England to gather matter for a "Character of Mary-Land," naïvely confirms many points in Smith's description. The amazing stature, the personal dignity and courage of the group of *Ongwe Honwe*[1] who until almost 1700 kept their grip on the great waterway of the Susquehanna—in the face of repeated thrusts from Senecas, Oneidas and white intruders—stands well documented on the page of history.

Nor is archeological evidence wanting to sustain the verbal. Skeletal remains of great size, stone pipes carved with animal and human heads, and pottery of rare design have been unearthed on Susquehannock sites, both at Safe Harbor, near the Chesapeake, and on the northern reaches of the Susquehanna—at old Tioga Point on the Pennsylvania border, and along the New York State tributaries. For Captain Smith's map, it will be recalled, locates five *Sasquesahanough* settlements to the northward—Testnigh, Attaock, Utchowig, Cepowig and Quadroque—unvisited, to be sure, but reported by trusted Indian advisers.

Closer scrutiny of the evidence, however, is needed to convince the cautious; and the witnesses form so picturesque a crew, no pretext to hale them into court can be rejected. First of all, in point of time, come the Swedes. Sent over-

[1] The name applied to themselves by the Iroquoian group as a whole, signifying "real men."

seas to actualize the dream of a New World state outside the vicious circle of religious wars, they bought land of the Indians, built Fort Christina on the Delaware, and began a lucrative trade with the Susquehannocks. Christine, to be sure, had less of a finger in this colonial pie than local patriots are prone to assume. In 1639, though technically queen, the gifted and eccentric daughter of Gustavus Adolphus was still in her early teens, and the guiding hand in the enterprise was presumably that of Oxenstiern, her minister.

In "Nya Sverige," a grandson of the first pastor-missionary of the colony, Johan Campanius Holm, preserves for us a vivid picture of the "Minques."[2] Commanding a rich inland country, this aboriginal "nation," in exchange for axes, cloth and kettles, offered the furred skins of the beaver, fisher and mink—all greatly in demand among the wealthy burghers, princes and prelates of the Old World, to edge their sleeves and line their ceremonial robes. The palisaded "fort" occupied by this tribe was situated on a high mountain, distant twelve miles (equivalent to 93 English ones) from the Delaware, across a difficult country, full of sharp gray stones and hills and morasses. The occupants of the fort were renowned for their warlike character, "having made the surrounding tribes subject and tributary. . . . They are a tall people," the text continues, "not frightful in appearance. When they are fighting they do not attempt to fly (the usual tactics of the Indian) but all stand like a wall as long as there is one remaining"; and more of the same admiring and respectful tenor.

The accounts left by the Jesuit Fathers and La Salle are no less adulatory. From 1640 to 1679 the "Relations" are full of the exploits of the *Andastes* or *Gandastogues* (the French name for the Susquehannocks, signifying "people of the curved roof-pole"). The Fathers took to themselves no little credit for a Susquehannock convert, one Arenhouta; through whose offices, they claimed, this mighty group of warriors was drawn into alliance with the Hurons against the restive and intractable Five Nations. If the incident is not overrated, the Christian Arenhouta played indeed a fateful rôle in the annals of his tribesmen. For the mortal ire of the Iroquois was roused by the Huron-Andaste compact, and the destruction of the latter group forthwith resolved upon.

In the relation of the retaliatory raids that followed, the number of warriors in the Susquehannock forts, their use of European modes of defense, of guns and cannon, are meticulously set down. In the pages of the Jesuits, fleets of war canoes dash up and down the river, from headwaters to the bay and back, at a speed excluding any doubt (in the minds of those who know the course) of the skill and intrepidity of the boatsmen. As for the further exploits recounted in these annals—of the band of sixty Andaste boys who vanquished as many adults, of the warrior who, single-handed, repulsed a raiding party of 400 Oïogouens—their parallel is discoverable in the chronicles of Sparta only—with which, no doubt, the Fathers were sufficiently familiar.

Less unimpeachable but vastly more diverting is another contemporary record—the account of the "wild and naked Susquehanocks," appended by young George Alsop to his "Character of the Province of Mary-Land," above cited, printed in 1666. First of the super-salesmen of America, Alsop was despatched to the colony under a four years' indenture, commissioned, it appears, by Lord Baltimore or his agents to compose a blurb on Maryland. Frugal Roundhead had replaced snuff-

[2] A generic and unflattering term signifying "stealthy adders," applied often indiscriminately to all their aboriginal neighbors by the Dutch and Swedes.

taking Cavalier in Old England, the consolatory offices of nicotine in a "depression" were as yet unexploited, and in 1649 the bottom had literally dropped out of the tobacco market. The young colony across the seas, whose main dependence was on this staple, was in distress. Laborers and colonists were difficult to attract, and the youthful poetizing Alsop was picked for the job of "selling" Maryland.

Tobacco advertisements were luckily not in the bargain. For young George, replying to a brotherly request from across seas for "some Smoak," remarks with acerbity that the only office of the latter is to "exorcise or affright the Devil." Yet here if ever was a man whose inmost being craved the solace of a pipe—if one may risk an opinion on the portrait which serves as frontispiece to his little volume. Pensive, misanthropic, devoid of any shred of humor, his face looks out from its frame of wavy locks, on a world whose chaos, he mournfully declares, is "matched only by his own soul's confusion."

After a "blowing and dangerous passage" of five months, however, Maryland, "in all her greene and fragrant mantle of the spring," looked very Eden to the ycung apprentice. His spirits rose. Euphuistic and yeasty in diction by temperament or training, never using one word when six would serve his purpose, he achieves, for all his verbiage, an unforgettable picture of the province. Its sports of hunting and fishing, the fifty-pound turkeys that lurked in its woods, the innumerable wild fowl that rose from the bay like a great dark tidal wave, all receive fitting tribute.

Inserted in his "Land-Skip of Lord Baltimore's Plantation," appear two Adam-and-Eve-like figures of the aborigines (obviously cribbed from the Sistine ceiling). Accompanying them are amusing sketches of the various species that followed Noah into the Ark —boar, wolves, foxes, raccoon, a bear testing his claws on a palm-tree. The text takes pains, however, to assure the future visitant that the "staring visages of the wilde Animals need not affright him," that he may walk in the open "with as little fear of being externally dissected as though he were in his own dwelling." The ladies alone of Maryland appear to have fallen short of the writer's expectations. He records them talkative, insensitive to the charms of courtly rhetoric; and subscribes one of his effusions plaintively, "From the Chimney-corner, on a low cricket, where I writ this in the noise of some six women."

Although Alsop modestly declares that his observations were made in the main from the safe shelter of a tree, his opportunity for noting aboriginal traits was certainly exceptional. The four years of his indenture were served on the northern outskirts of the province, on the estate of one Stockett, whose special office was the issuing of passes to Susquehannocks who wished to approach nearer to the settlements, across the bounds set by treaty.

"The most noble and heroick Nation of Indians in the confines of America," our young apprentice pompously pronounces them; "cast in the mould of a most large and warlike deportment, the men being for the most part high in latitude, their voyce large and hollow, as ascending out of a cave, their gate and behaviour strait, stately and majestick, treading on the earth with as much pride, contempt and disdain to so sordid a Center as can well be imagined from a creature derived from the same mould and Earth."

This impressive and Miltonic picture is marred by one blemish only. The Susquehannock, Alsop avers, worships the devil himself, sacrificing to him a child every fourth year. Cannibalistic

rites are furthermore declared to attend the war raids of the group. The accusation gives us pause—it appears to have been overlooked by the original underwriters of the "noble savage." It is true the Susquehannocks were sometimes known as the "Demon People," *Askikouannhe*. It is unclear, however, whether this name refers to their size and fierce and aggressive character or whether it derives merely from the many caves and waterfalls along the course of the Susquehanna; for these natural features, in the Indian cosmogony, are the peculiar creation of the evil one.

Boocootawanough, we know from other sources, they were also called—destroyers, or as some versions have it, flesh-eaters. With all the Konoschioni, however, the eating of human flesh, it will be recalled, was a sacred rite—a kind of eucharist. For their animistic (and totemistic) beliefs made it wholly likely that the spirit of a valiant enemy would be assimilated with his flesh and blood. Eloquent expression of some such conviction may be detected in the statement of the old chief, who declared that brandy must be made of hearts and tongues, since after tasting it his courage was always higher, his speech more fluent.

This peculiar defect in manners or in morals, noted by Alsop, appears somehow to have escaped the notice or the censure of the early romanticists and back-to-naturists. For the verdict on the superiority of the Susquehannock, both over his own kinsmen and over the effete city-dweller, has come down the centuries to us virtually unchallenged. To verbal evidence, the mute witness of archeological finds on the lower and upper reaches of the Susquehanna, above referred to, is steadily accruing. Many years ago, in northern Pennsylvania, a burial ground was opened at *Teaoga*—believed to have been the site of Champlain's palisaded village of Carantouan, later the southern door of the mythical Long House of the Six Nations. Skeletal remains of great size, in a state of preservation indicating long interment, were unearthed. Buried with them, in primitive fashion, were artifacts of rare design: carved stone pipes, turtle-shell rattles, jars ornamented with intricate geometric patterns and extraordinarily modeled human faces—whatever the dead might need on their long journey.

In the last two years, at Safe Harbor, these remarkable findings have been duplicated. Huge stone pipes with carved animal heads, bone combs adorned with human figures, fish-hooks and harpoons of unusual pattern also, with beads, wampum and pottery of a vast range of sizes are among the spoils. No vestige of doubt remains that the feminine artisans of the tribe (for Susquehannock craftsmen were always female) were as preëminent along artistic lines as its warrior huntsmen were renowned in all that relates to physique and action.

The mystery deepens. Here was a splendid people, highly endowed, adaptable, adopting white men's ways and implements (where their superiority was patent), yet destined like their prototypes, the primitive Crô-Magnon, to disappear from the earth, replaced by inferior stocks.

A closer scrutiny of the records, however, resolves in part the enigma. The Susquehannocks were fairly caught in the steel trap of civilization. Their very avidity for white man's goods—guns, axes, cannon—the numerous contacts with white soldiers and traders that resulted, exposed them to sudden inroads of new diseases (notably smallpox in virulent form), with no chance for a gradually acquired immunity. Furthermore, their beloved river was a key site, at once an important artery of the fur

traffic, and far too easy an avenue of approach to the low-lying, defenseless shores of its great estuary, the Chesapeake. Coveted on the one hand by their jealous kinsmen to the north, it was the pivot also of schemes for defense, for territorial and commercial expansion of the Penns, the Baltimores and the neighboring colonies to the east —New York, Delaware and "New Jarsy."

Fairly early in the seventeenth century, it appears, Maryland saw the advantage of using the Susquehannocks (strongly fortified on the lofty crags of their great waterway) as a buffer against attacks from the Senecas, Cayugas and Oneidas. For the imperial ambitions of the latter were already sprouting, and swift raids on southern tribes along the bay, or on defenseless colonists, kept the nerves of the province in a continual twitter. A treaty pledging eternal friendship, sealed by a silver medal on a black and yellow ribbon, long cherished, was therefore made; and guns and officers for the fort on the lower river promised. Presently, however, there arose on the horizon a new menace—William Penn, the Quaker, seeking a foothold on the Susquehanna for his co-religionists.

Owing either to the sheer muddleheadedness of the charter-granting Stuarts or to their geographical ignorance, a spirited boundary controversy between Baltimore and Penn was shortly under way. The site of the Susquehannock fort was the pivot of the dispute, which dragged on far into the next century. Traders' affidavits that the fort of the boundary agreement lay to the southward, at the mouth of the Octoraro, were assiduously garnered by the Penns; while Lord Baltimore rewarded with a manor one Augustine Herrman, on whose beautifully executed map of 1670 the disputed fort appears far to the northward, on the west bank, near the mouth of the Conewago. Impartial opinion, it is fair to add, locates the original fort midway between these two sites, on the east bank, possibly on Turkey Hill.

Now whether the Susquehannocks—a catspaw to white ambition—were bribed by Baltimore's agents to shift their location from a lofty crag on the left bank to a low-lying, less strategic point on the right, is not clear. It is known that Maryland presently, in a spasm of fear, turned on her former allies (whom a sudden onslaught of the Senecas had driven down the Bay and up the Potomac and the Piscataway). The last band of the Susquehannock warriors, among them that picturesque old irreconcilable, Hochitagagete or Barefoot, along with five other sachems, were ignominiously slaughtered. Was it poetic justice that a few years later the coup of the astute Penn succeeded and Maryland lost a twenty-mile slice off her northern borders—the very heart of the old Susquehannock territory?

Thus ingloriously, about 1676, the extinction of the Sasquesahanoughs appears to have been effected. But did the originals of the "noble savage" actually perish from the earth, leaving no vestige except the eulogies of their admirers and the funeral pottery of their dead? Closer scrutiny of the records engenders doubt. Like many primitive and imaginative people, the Iroquoian cherished the peculiar custom of blood-adoption. With equal faith in heredity and environment, in the power of the totem and in sympathetic magic, they were wont to fill the gaps left by war losses with the bravest captives; replacing thus a missing brother, father or husband, as the case might be. Old maps and records show that at least a hundred of the finest Susquehannock warriors were thus disposed of, partitioned among the Oneidas, Onondagos, Senecas and Cayugas—each canton vying with the others for her share of living booty.

Little imagination is required to trace the finger of these transplanted Susquehannocks in the Confederacy's later history. A peace was presently patched up between the Iroquois and the neighboring colonies; but resolutely, for a hundred years and more, the intrusion of white settlers along the Susquehanna was resisted. Is it fanciful to discern in the eloquent, defiant speeches of the great sachems dispatched from Onondago to the conferences at Albany, Lancaster and Philadelphia the determination of the Susquehannock braves to exclude white intruders from their hereditary hunting-grounds in central Pennsylvania? For many years an Iroquoian agent was stationed at Shamokin (now Sunbury) for the express purpose of regulating liquor traffic and forestalling the careless signing away of land-rights to representatives of the wily Penn or Andros. "The land lasts always, but the goods waste soon away," was the oft-repeated caution of the sachems (Susquehannock, shall we doubt?) to young hotbloods, when colonists came seeking new concessions.

So much for eighteenth century evidence of Susquehannock wit and resolution, absorbed but unsubmerged in the Confederacy. Even to-day, it is said, in certain of the Pennsylvania and New York State reservations, a sprinkling of large-boned men, of stature more than average, suggests the survival and outcropping of certain dominant physical traits of Captain Smith's Sasquesahanoughs.

A subtler dénouement, however, intrigues one's fancy. Not long since, a visiting Englishman excited much derision by remarking that in all American colonial stock there must be an infusion, however slight, of Indian blood. Perusal of old documents lends color to this hypothesis. Casual interbreeding at trading-posts of course enters into the picture. But far more arresting are the multiplying tales of white captives, brought up in Indian long houses, sending back their descendants to the colonies. Who knows but that the finest of our native Pennsylvania stock contains a tincture of old Susquehannock? Virginians boast of their descent from Pocahontas. As interesting escutcheons might be fashioned if all good Pennsylvanians ransacked their family letter-files and journals for evidence of a blood-strain of their gifted predecessors —the artist potters and intrepid huntsmen of the Susquehanna—the originals of the "noble savage."

GRASSES AND MAN

By MORRIS HALPERIN
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HUMAN life has been and is more dependent upon grasses than upon any other group of living things.

GEOLOGIC GRASSLANDS AND PRIMITIVE MAN

The Miocene epoch is characterized by the formation of extensive grassland areas which replaced the swampy vegetation of the preceding epochs. It also presents a world-wide prevalence of the ancestors of most grass-eating (herbivorous) mammals. These animals, by contrast with their weak-toothed and short-limbed ancestors, possessed long-crowned and strong teeth adapted for grinding grass and relatively long feet adapted for running over hard and dry grassland in search of water and to escape from enemies. The abundance of grass favored the multiplication of the herbivorous mammals. This in turn furnished an increased food supply for flesh-eating (carnivorous) animals, and, as a consequence, these also increased in number. The grasses were thus the controlling influence in the Age of Mammals.

The human importance of this fact is that primitive man was obliged to follow these animals—his almost exclusive food supply—as they wandered from grassland to grassland. Even after he domesticated certain of the mammals—the horse, ox, sheep, goat, pig and dog—he continued to be a nomad because he still had to herd these animals from one favorable grassland to another. Virtually all primitive men were characterized by this wandering life until certain of them, in various parts of the earth, observed that several of the grasses which their animals ate produced seeds which were not only edible food but were capable of remaining so for a considerable time. Man, in other words, discovered that he could store good food for himself. Thus man ceased to be dependent entirely for his food upon his animals, which in turn fed upon the pasture grasses. The cereal grasses became a direct portion of man's diet and furnished him with some nourishment which he could obtain by staying in one place.

By thus becoming a grass-eater, man changed his life from that of a nomad to that of a settler. This change was tremendously important for mankind of all times. There have not been any beginnings of civilization apart from agriculture. The earliest known argiculture was the cultivation of the cereal grasses, which resulted in the conservation of the human energy formerly wasted in roaming, in a sense of ownership, in the development of tools and appliances from various metals, in periods of leisure time during which thought, language, literature and art could make their first appearance in human life, in the beginning of settled and social life, and, in fact, in the introduction of most aspects of civilization.

Every known primitive civilization was built directly upon one or another of the cereal grasses, sometimes supplemented with pasture grasses.

CIVILIZATION IN ASIA

In Japan, millet and rice were cultivated since primitive times.

Human life in China, in the Indian Archipelago, in the Malay Peninsula and in the Philippine Islands, was dominated by rice.

The primary food of the Aryans in northern India consisted of rice. Bar-

ley and sugar cane were also used extensively. The Aryans had pasture-lands on which they grazed their animals which furnished meat and the means of transportation. Guests and gods were honored by being seated on grass mats. To their gods, they offered up roasted grain (probably barley) and cooked rice.

The Proto-Nordics were an entirely pastoral people. They were nomadic and followed grasslands in central and western Asia. The invasions of the Huns, Tartars and Mongols were motivated by the necessity of finding new grasslands for their animals.

In Persia, wheat was the chief constituent of human diet.

In Babylonia, about 3100 B. C., land was paid for by bronze and by grain. At about 1400 B. C., there was an appliance for plowing the land and sowing the seed of grain in the same operation. In 450 B. C., the historian Herodotus wrote: "The soil is peculiarly adapted to grain; no fruit trees are grown; only barley, wheat, and millet are grown."

In the palace of the King of Iberia stood gold and silver vessels filled with barley juice.

The Hebrew patriarchs were shepherds of animals on grasslands. Joseph, in his first dream, saw "sheaves of grain." Moses promised the Hebrews that "He (God) will put grass in your fields for your cattle." Nearly all of the religious sacrifices included a grass-eating animal or grain of the cereal grasses. The story of Ruth is built around barley and wheat. There are numerous other references to grasses in the Bible.

Civilization in Africa

In Egypt, wheat and barley were cultivated by 4000 B. C. In the Egyptian "Book of the Dead," King Osiris states: "I am Osiris. I live as Grain. I grow as Grain. I am Barley." The Pharoah of Joseph's time, in his first dream, saw seven fat cows grazing in the meadow grass, and his second dream pertained to "seven ripe and seven thin ears of grain" (probably barley).

In other parts of Africa, civilization was based on another group of grasses, the sorghums. Barley and millet also were important articles of food.

Civilization in Europe

In what is now Switzerland and northern Italy, the chief crops cultivated by the Lake-dwellers were barley, wheat and millet. Wheat was cultivated in Hungary during the Stone Age. The Macedonians, when invading Asia, became familiar with the cereal grasses grown there and introduced them into their own country as food-crops.

In Rome, the first known reaper was invented in connection with the harvest of grain. Polenta, a porridge made from barley, was fed to gladiators who were called *hordeari* from *hordeum*, the Latin name for barley. The word "cereal" is from the Latin "*cerealia*," which were grain festivals in honor of the goddess Ceres.

The Lithuanians, Germans, Celts, Gauls, Illyrians, Thracians (in modern Hungary) and Numantians (in modern Spain) ate millet, barley and wheat, and drank beverages made from these grains.

Civilization in America

The physical, social and religious life of the Mayas, Aztecs, Incas, Guatemalans, Peruvians and other American peoples was based on maize or Indian corn.

The early settlers in America brought with them from Europe seed of rye, wheat, oats and barley, and planted these for crops as early as 1625.

Other Aspects of Civilization

The calendar came into existence as a matter of necessity connected with cereal agriculture. Nomadic life required no calendar; the natural division of time into day and night was sufficient.

But the cultivation of the cereals, to be successful, required a calendar according to which planting and other agricultural operations could be performed at the time found by previous experience to be best. In the earliest Babylonian calendar, the names of eight of the twelve months of the year refer to grain. In the Egyption calendar, certain of the names of the months also refer to cereals —"Sprouting of the Grain," "Making and Watering Barley," "Ripe Grain," and "Lady of the Granary."

The earliest problems in various branches of arithmetic concerned grasses —their agriculture, their conversion into flour and loaves of bread, and their distribution to the laborers. Some of the beginnings of geometry were likewise related to grasses—the measurement of the areas of grain fields and the consideration of various forms — cylinder, rectangle, or parallelopiped — as the most economical shape for granaries. What was probably the very beginning of astronomy was the institution of observing the moon as a basis for performing the steps in the cultivation of the cereal grasses at certain times. (Many people, even in civilized countries in this century, plant seeds of crops according to the moon.)

There were a few plants other than grasses which were cultivated before historic times, *e.g.*, the soybean, date-palm, hemp, flax, peach, apricot and grape-vine. In no case, however, was any civilization dependent upon any of these plants, whereas every known civilization has been made possible and necessary by the cultivation of one or another of the cereal grasses.

Characteristics of the Grasses

The grasses are apparently ideal pasture-plants because, instead of growing as other plants do, at the tips of the leaves which are eaten off by the grazing animal, grasses grow at the joints, the lowermost of which are generally inaccessible to the animal's mouth and are therefore uninterrupted in their growth. This explains, too, the ability of lawn grasses to continue providing a turf in spite of frequent cutting.

As food for man, a cereal grass produces each year a large yield of edible, storable and transportable food, containing a great deal of nutriment for its volume. The grasses, in addition, grow in a greater variety of conditions of climate and of soil than do any other large plants. Grasses are the chief plants which possess all the characteristics in the right proportion for constituting man's basic food.

Uses of Grasses

Food

Bread is still the "staff of life." Breadstuffs, furnishing the sole or chief food of most of mankind, are made from grasses.

As for meat, it is true almost literally that "all flesh is grass." Animals feeding on grasses furnish beef, mutton, pork and poultry, and such by-products as milk, cream, butter, cheese, oil, eggs, wool and leather.

Most of the world's supply of sugar is made from the grass, sugar-cane. Molasses is made from sugar-cane and sorghum. Beers and similar beverages are made by fermenting the seeds of grasses—maize, barley, rice, bamboo, millet and others.

Grasses, in the form generally consumed by man, are deficient in both minerals and vitamins and must be supplemented, if growth and health are desired, by fruits and vegetables.

Building Material and Land Reclamation

Where the bamboos grow, they constitute the material out of which houses, furniture and scores of other construction objects are built. Grasses are used in the tropics to build huts and tree-houses.

For the reclamation of useless or troublesome types of land, grasses are the leading plants. Beach grass is the pioneer for reclaiming sand-dunes in the temperate regions of the world. Cord ("Rice") grass (*Spartina spp.*) is the prime plant used to reclaim mud-flats and tidal estuaries. Both of these plants are used notably in North America and in Europe. For reclaiming alkali lands for agricultural utilization, several grasses are the best adapted plants known.

Grasses in the Landscape

Grass lawns render houses and other buildings attractive. Parks owe much of their beauty and probably all of their utility to grass. Golf courses and athletic fields are grass turfs. Some grasses are used as ornamental plants in gardens, *e.g.*, bamboo, pampas grass, zebra grass, quaking grass and "gardener's garters."

Miscellaneous Uses

A small portion of the world's supply of paper comes from grasses. "Straw" hats are made from the stalks of various grasses. Whisk-brooms and sweeping-brooms are manufactured exclusively from a grass known as broom corn. The standard feed for birds is the seed of canary grass. Fishing-rods, and the vaulting poles used in Olympic games, are the stems of bamboo.

Corn stalks yield furfural, which is used as a solvent in resins and lacquers, and as a preservative in veterinary embalming material. Corn-starch is used in the stiffening and finishing of textiles, as a finisher and filler in the manufacture of writing-paper, as a stiffener in laundry work, and as a constituent of baking-powder, pies, puddings, soap, paints, adhesive substances and asbestos products.

The bamboos furnish cooking and other domestic utensils, musical instruments, hats, smoking-pipes, clothing and literally hundreds of other every-day needs of millions of people living in the tropics.

The grasses cause more hay fever than probably any other group of plants. Although constituting one of the largest families of plants, the grasses contain hardly any poisonous representatives, only the stunted or second growth of the sorghums being poisonous to animals.

Extent of Grasslands

Grassland is the prime form of vegetation on the Great Plains and prairies of North America, on the savannahs and pampas of South America, on the veldt covering immense areas of Africa, on the enormous steppes of Russia, Siberia, China and Manchuria, on the grasslands of Australia and New Zealand, and on the lesser grassland areas distributed elsewhere on the earth's surface.

Much land is covered with cultivated grasses. For example, Indian corn is grown in the United States on over 100,000,000 acres, a greater area than that of California. Similarly, rice, wheat, barley, millet, oats, sorghum, sugar-cane, bamboos and pasture grasses cover very large areas of the earth's surface. In all probability, grasses occupy a greater portion of the dry surface of the earth than all artificial and other natural formations combined.

Grasses grow in the Arctic regions, where they constitute approximately one fourth of all the flowering plants and are more numerous than any other single family of large plants. Grasses grow, by contrast, in the hottest portions of the tropics. They are found at sea-level and on the highest mountains, in the open and in shade, on plains and on hillsides, in water and in sand, in forests and in deserts, on alkali soils and on acidic soils. In fact, grasses are found, often to a dominant extent, in any environmental condition in which plants can grow.

The family of grasses contains a larger

number of individuals than all other families of large plants combined.

Value of Grasses

The most valuable crops in the world are grasses—the cereals, sugar-cane, bamboo and hay. Statistics do not include the grass on ranges and pastures which is consumed directly by animals without going into commerce, where its value can be recorded. In the United States, maize, hay, wheat, barley, oats and rye have an annual worth of about six billion dollars.

Summary

The geologic Age of Mammals was, in large measure, made possible by the formation of grasslands.

The almost exclusive food-supply of primitive man was the meat of the animals which lived upon grass or which preyed upon grass-eating animals. Early man was a nomad, following these animals from one grassland to another.

Every known civilization had its beginning in the cultivation of one or another of the cereal grasses.

At present, grasses furnish all the breadstuffs and most of the meat and sugar consumed by man. They also supply housing material for millions of people in the tropics.

Grasses are adapted for growth in a greater diversity of environmental condition than are any other large plants. Probably the greatest portion of the earth's dry-land surface is covered by grasses.

In general, human existence and civilization have thus far been very closely related to the natural and agricultural importance of grasses.

COOKING CAMAS AND BITTER ROOT

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Now that the old way of life is passing so quickly in western Montana, the local anthropology staff is frequently asked about the ways the Interior Salish tribe of Flatheads (improperly so-called) prepared their staple vegetable foods, the root of the camas (*Quamasia quamash*), and the bitter root (*Lewisia rediviva*). The process is becoming increasingly difficult to observe. For with every recurring bitter root season, we notice fewer and fewer tipis pitched on the flats south of the university. The culture of the Salish is passing, along with their grand old men, whose descendants are not content to be Men Without Machines. The rapid diffusion of the easy Woolworth-pot-and-pan complex has perhaps made the following cooking method impossible ever to see again. I am deeply indebted to my friend, Mr. John Frohlicher, who has lived longer among the Salish and has witnessed the preparation of the feast untainted by white culture oftener than I have, for this description.

The roots of the two foregoing plants have been, and to a considerable extent still are, the primary cause of the spring-time tribal movement of these semi-nomadic people from their winter game areas around Flathead Lake to the regions where the plants are plentiful. The camas root is found in appreciable quantities north of Flathead Lake on the old lake bed, and southwest of the lake on its former channel to the Columbia. The bitter root is found in great quantities on the flats on which the city of Missoula and the campus of the State University of Montana now stand, as well as in the Bitter Root Valley, which extends many miles south of Missoula.

It must be remembered that these peo-

ple of the northern part of the Plateau culture area are tribes without pottery or even basketry, unless they could trade with their cousins, the Nez Percès, for the latter. The ancient method of preparing the camas bulb is a variant of the pit-baking process. A pit about 10 feet long and from 2 to 3 feet wide is dug, and a fire of intense heat is therein kindled. The Salish prefer to use cottonwood limbs and bark for this fire, since they burn longer than the conifers so plentiful in this region.

When the wood is reduced to glowing coals, red willow sticks with the sap still in them are crisscrossed over the fire-bed in the form of a gridiron. Over this is laid a blanket of green grass, ordinarily the abundant bunch-grass, some 2 to 3 inches thick. Upon this, in turn, is placed a layer of moist earth. The final layer of this blanket consists of another coating of green grass. Then the camas roots are dumped into the pit. The mass is covered with more grass and a thick layer of earth. Another fire is now kindled on top of the heap, and kept alive from twelve to eighteen hours, when it is raked away and the oven opened for the prepared food.

The camas roots are then found cooked to the consistency of boiled beets. They are sometimes eaten raw. But in that state they have an unpleasant bitterness which is lost in the cooking. Actually, the camas bulbs have very little nutritive value, and, like our cooked onions, should be considered a condiment.

The bitter root is considered edible only when the plant is in flower. So at the time when this charming blossom is dotting the valleys, the tribesmen gather at the sites where the herb is plentiful. The women and children are then busily engaged in digging the roots while the gentlemen amuse themselves. The older Indians assert that the common way of cooking bitter root in the old days was similar to the hot pit method described for the camas. However, the root was often dried for winter use and stored in parfleches. In this instance, they were usually ground into a flour, a paste made and baked into cakes about the size of a small pancake. Modern Salish have discovered that the cakes keep as well as the unprepared dried roots, and are very apt to save labor by cooking their winter's supply into cakes immediately after the harvest. As it is said of olives, the bitter flavor of these cakes does not often appeal to the novice, but a taste for them may be acquired.

As with modern military empires, the ecology of the food plants and animals of the Northwest had profound effects upon the relations of the Flatheads with their neighbors. The camas and bitter root are not found on the semi-arid plains, and the Plains type Indians, lacking adequate vegetable food, sought treaties with the Salish monopolists, enabling them to enter the valleys and gather the plants. In exchange for this privilege, the Plains people were to permit the Salish to enter the eastern grass lands in search of the bison. However, these treaties were rarely kept. The militant Piegan Blackfeet often scorned to ask permission of the Salish, whom they despised, to enter the valleys to gather roots. On the other hand, the Salish, seemingly bent on losing their hair, claimed an inalienable, ancient right to enter the Plains whenever they saw fit. These treaty rights and the violation of them made this country a shambles for centuries. Whatever else may be charged against the white man in western Montana, and his record is no more honorable than need be, his presence and that of his army undoubtedly kept the fierce Blackfeet from completing the process of exterminating the numerically inconsequential "gentle Salish" whom Lewis and Clark loved.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

HEAD HUNTERS OF THE AMAZON

By MATTHEW W. STIRLING

CHIEF OF THE BUREAU OF AMERICAN ETHNOLOGY, SMITHSONIAN INSTITUTION

THE curious custom of preserving human heads taken in warfare has been practiced by primitive peoples in several parts of the world, but in no region is this activity pursued more vigorously nor in so specialized a fashion as by the Jivaro Indians of South America, who prepared their captured heads by shrinking them to the size of a small orange while preserving perfectly the features of the victim. Having recently lived for several months among these Indians, I will try to describe to you their country and a few of their customs.

In eastern Ecuador, where the Andes fall away in range after range of jungle-clad mountains, there is a great basin, drained by the Upper Maranon and Santiago rivers. Entrance to it from the west is barred by the snowy peaks of the high Andes, while from the east a formidable obstacle to travel is presented by the famous Pongo Manseriche, the great gorge through which the combined waters of the Maranon and the Santiago burst through their final mountain barrier into the vast Amazonian plain. In this region of torrential streams and rugged mountains live upward of thirty tribes of the so-called Jivaro Indians. Isolated in this remote corner of the world, they have maintained their primitive customs almost unchanged by contact with the white man.

Warfare is the very center of existence to the Jivaro, and his entire cultural pattern is woven around it. War is conducted on the principle of blood revenge, the practice of which is a sacred duty which no Jivaro would dare refuse. Fathers begin instructing their small sons at the age of five or six years, lecturing them each morning when they first awaken on the necessity of taking blood revenge for his relatives who have been killed in the past. Their names are recited to him, as are also the names of the families and individuals who have done the killing. This instruction is rehearsed to the boy daily until he is about twelve years of age and thoroughly impressed with his duty. Small boys accompany their fathers on war expeditions before they are capable of bearing arms in order that they may become accustomed to the realism of killing and learn the tactics of warfare from direct observation. So actively is head hunting practiced that the women, who are generally not killed in the raids, greatly outnumber the men, thus making polygamy a social necessity. Three or four wives to a man are common and I know one Jivaro, much respected for his courage, who has twelve.

A Jivaro community consists of a single house, in which live not more than thirty or forty individuals, generally comprising a group of related families. This community house is strongly built, usually on the top of a hill or the edge of a bank, with an eye to its defensibility. The walls of the house are constructed of pickets of palm wood or bamboo lashed firmly together, and the high roof is covered with palm thatch. One half of the house is the exclusive

domain of the women, the other half is occupied by the men. Each half has its own door, made by setting logs vertically in a slot at the entrance.

Imagining ourselves in the house, we see lashed against the high center posts the long blow guns with their bamboo quivers of poisoned darts, which the Jivaros use as their principal hunting weapon. In the same position, standing upright, are the long lances of hard black palm wood which are the chief weapons of their war expeditions. Hanging from the center posts or lying on platforms over their beds of split bamboo are the big painted circular wooden shields used in warfare. The Jivaros do not have the bow and arrows, but many of the men use cheap muzzle loading shotguns, obtained usually by trading human heads.

Conspicuous in the center of the women's half of the house are a number of huge red earthenware jars filled with a mildly intoxicating drink called mesato. This drink, which is the central feature of all feasts and ceremonies, is consumed in great quantities by the Indians, to whom it is both food and drink. The women who make it prepare it by chewing manioc root and spitting the resulting mixture of starch and saliva into the jars, where it ferments. It is necessary for all visitors to a Jivaro house to drain a bowl of this drink which is always offered as a gesture of hospitality.

There are many causes of war, but by far the most common is the killing, or supposed killing, of some member of a group by some one in another group. Since it is a point of honor always to be one ahead of the other fellow, it is easy to see why the cycle of killings becomes almost endless. To further complicate matters, very few deaths are attributed to natural causes. If a man dies of illness, that illness is believed to have been sent into him by the medicine man of some enemy group. If a man is drowned in the river, it is because some enemy has caused the great river serpent to upset his canoe. The medicine man of his own group then takes certain drugs, under the influence of which he learns the identity of the culprit. This accomplished, a feast is held, much mesato is drunk and war is declared against the household of the supposed killer.

Custom demands that a warning be sent to the house which is to be attacked. As soon as this is received, the group to be attacked prepares pitfalls containing sharp stakes around the house and place set guns and traps on all the trails approaching. The attacking party divest themselves of all clothing and stain their faces and bodies black with a vegetable dye. Each man carefully prepares his hair and puts on his finest head ornaments. This preparation, they explain, is so that in case the attacker should have his own head taken he would have nothing about which to be embarrassed. A group of women accompany the war party in order to prepare their food.

The attack invariably takes place at dawn. Although the attacking party is by no means always victorious, we will assume for purposes of illustration a successful raid. The defending party, knowing of the impending attack, have tied dogs at various strategic points around the garden clearing which surrounds the house. Their barking gives warning of the arrival of the raiding force in the night. While awaiting the first sign of dawn, the two parties endeavor to terrify each other by loud shouting and the exchange of threats and insults. During this time the great wooden telegraph drum in the house is being pounded incessantly, while both groups dance wild dances and sing warlike songs. When the first traces of dawn appear, the attacking party, shouting at the tops of their voices, rush the

house and attempt to force an entrance. In the meantime the defenders fire upon them from between the wall pickets. When a breach has been made, the attackers pour in, fighting hand to hand with lances. The interior of the house becomes in the half light a scene of greatest confusion.

The shouting of the warriors, the screams of the women, the crying of children and the barking of the dogs mingle to produce an effect difficult to describe. The warriors, working in pairs, try to outmaneuver one another so as to get in their lance thrusts from behind. When all the men have been killed or have escaped, the small children and the old women are lanced and all the marriageable women are taken captive. Each fighter who has killed a man severs the head of his victim with his lance and wraps it carefully in a basket. The dogs are all killed, the plants in the gardens uprooted and destroyed, and the house itself is burned. A brief meeting is then held in which the captive women are apportioned as wives to various members of the victorious party, and any disagreements are settled as to who is entitled to the heads which have been taken. It frequently happens that some of the victims are relatives of members of the attacking party. In this case, these heads are not taken.

At a camp by a river the returning party stops to prepare the heads which they have taken. The heads are skinned much as one would peel off the skin of a rabbit. The skin is first reduced to one third its original size by a boiling process and further reduced and dried by applying hot rocks and hot sand. Finally the head is smoked, which blackens it and enables it to be polished as one would shine a shoe. The top of the head is then pierced and a cord attached in the form of a loop. The entire operation requires great skill. Young men preparing their first heads are instructed by experienced warriors, who sit by their side during the entire process.

When the party returns to its house, each victor wears the head which he has taken around his neck, suspended by the loop. Upon entering the house the heads are removed and hung upon lances thrust in the floor. The warriors are painted by the women and an elaborate ceremony follows, during which both men and women dance around the heads, singing and casting insults. While the dance is partly a dance of triumph, its purpose primarily is to bottle up the spirit of the victim in the shrunken head so that it will be unable to escape and harm the killer. For the same reason, following the ceremony, each victor must rigidly observe a number of taboos for a period of six months. There are a number of Jivaro men living today who have taken as many as forty or fifty heads in their time. This curious custom, which seems so revolting to us, is not the result of any unusual strain of cruelty in these Indians. In other respects they are as kindly and as capable of tender sentiments as any civilized group. Their fighting follows a recognized set of rules, and killings are never perpetrated without what they consider a just cause.

In most other respects their morality might well be taken as a worthy model for civilized man. The custom of head hunting evidently had a long period of growth which in time fixed it so firmly into the cultural anatomy of the Jivaros that they now can not imagine existence without it. Before we criticize them too severely, we might first examine our own social structure. Some of our undesirable customs are a bit more subtle than that of head hunting; and if we do not have any one custom as bad, at any rate we have more of them.

"CONCERNING DRAGONS"

By CHARLES W. GILMORE

CURATOR OF FOSSIL REPTILES, U. S. NATIONAL MUSEUM

MANY millions of years ago this world was inhabited by a race of strange reptiles upon which science has bestowed the name of dinosaurs. Although all these animals disappeared millions of years before there were any people in the world, from a study of their fossilized remains it has been possible to learn how many of them looked when alive, what they ate, where they made their homes and in some cases how they died.

The name dinosaur is usually associated with an animal of great bulk, having a long tail and neck, but in addition to this popular conception there are many other kinds. While it is true that some were the biggest land animals this world has ever known, there were also living at the same time some that were very small. They differed greatly in shape, structure and habits. Some walked on all four feet; others, with small weak fore limbs, walked upon strongly developed hind legs like ostriches. Some were provided with long sharp claws; others had flattened hoof-like nails. There were dinosaurs with small heads and others with very large heads. Some were big and cumbersome, others were small, light and graceful and so much resembled birds in their structure that only the skilled anatomist is able to distinguish their fossil remains. Some of large size were clad in coats of bony armor, giving them a bristling appearance. Some were flesh-eaters and others fed only upon plants.

In size the largest of the dinosaurs exceeded one hundred feet in length. An actual skeleton of one of these huge reptiles in the U. S. National Museum in Washington, known as *Diplodocus*, measures over seventy feet in length and stands over twelve feet high at the hips. Taking *Diplodocus* as a typical example of the largest of these animals, this dinosaur may be said to consist principally of tail and neck with a short body between, that is, supported by four stout elephantine-like legs, its proportions being: tail forty-eight feet, body twelve feet and neck twenty feet. At the end of the neck is a small head about the size of that of a horse. It is estimated that in life *Diplodocus* weighed twelve or more tons. The wonder of it all is how did an animal of such great bulk manage with such a small mouth to secure food enough to sustain itself. Certainly eating must have occupied all its waking hours.

With this brief sketch of the largest of the dinosaurs, let us consider for a moment some of the other kinds. The smallest dinosaur known is but a little larger than a chicken, and is remarkably bird-like in its structure. It walked around entirely upon its hind legs, the body being balanced by a long tail. Then we have the hadrosaurs or duck-billed dinosaurs, also walking on two feet, that were plant-eaters, and of many different kinds, large and small, some with high bony crests on the top of the head, suggesting the comb of a rooster. One of the striking peculiarities of these animals is the development of a remarkable battery of teeth; ofttimes there are as many as 2,000 teeth in the jaws of a single individual. These teeth are arranged in longitudinal and vertical rows, and when a tooth is worn out or lost through accident, the next tooth below moves up to take its place, thus insuring a full dental series throughout the life of the individual, which in this respect gives these animals a decided advantage over ourselves.

Usually only the hard parts, bones and teeth of the skeleton are fossilized, but under exceptional conditions impressions of the external covering are occasionally found. Such skin impressions have been found with several specimens of the duck-bills, so that now we have a very definite idea of their external appearance. It is known that they were covered with a scaled skin, made up of small horny scales which are arranged in beautiful mosaic patterns. This skin pattern is also known to differ in the different kinds of dinosaurs.

The outstanding discovery of recent times concerning the habits of the dinosaurs was the discovery in Mongolia of fossilized eggs. It has been long surmised that these reptiles reproduced their kinds through the medium of eggs, but this was the first positive proof of that fact. The largest of these eggs were about the size of those of the ostrich, cylindrical in shape, a form characteristic of many living reptiles. We are told that as many as nine were found together in one place. One of these eggs is said to contain an embryo.

There lived at the same time with the dinosaurs previously méntioned, all of which were plant eaters, both large and small flesh-eating or carnivorous dinosaurs. The giant among these is known as *Tyrannosaurus,* the tyrant saurian. It reached a length of forty-seven feet, and in a standing position, which was entirely on the hind legs, was eighteen or twenty feet high. The head was over four feet long, and the long powerful jaws were provided with sharply pointed teeth from three to six inches in length. To this powerful armament was added the great sharp claws of the hind feet and probably those of the fore feet, curved like those of the eagles, but much longer, being six to eight inches long. This animal was one of the largest and probably the most ferocious beast that ever inhabited this old world of ours.

There were others of intermediate size, like *Triceratops,* the dinosaur with the three-horned face, for that is what the name implies. These horns grew one over each eye and a smaller one on the nose. The large horns above the eye sometimes are more than a yard in length and are sharply pointed. Skulls of these animals reach a length of over eight feet, due to the development of a bony frill that extends backward over the neck like a fireman's helmet. This is the largest-headed land animal ever known, the skull being about one third the total length of the entire animal. Although the horned dinosaurs were plant feeders, they often engaged in combat, as is shown by the healed wounds that are found in many a skull, broken horns and in fractured and healed jaws and other bones of the skeleton.

Another group with striking peculiarities are the armored dinosaurs, so called because of the development of an armor composed of bony skin plates. The most peculiar member of this group is one whose remains are found near the close of the age of reptiles and has been popularly designated the "Super-Dreadnaught of the Animal World." Picture in your mind a short, squatty animal, perhaps twelve feet in length, with a body nearly five feet in width, short massive legs, heavy tail and a small flat-topped triangular skull. The back is covered with innumerable little nodules of bone that were embedded in the skin, and at intervals were set, in more or less regular fashion, large flat plates and spines. On the end of the tail there was a great thickened triangular mass of bone appropriately called the "tail-club." The head was turtle-like and was provided with a broad rounded horny beak used to nip off the vegetation. Even the eyes were protected by a bony cup-shaped shutter that could be closed over the eye when the animal

so desired. Thus protected by his covering of bony armor, this animal was in reality an animated fortress, and need have no fear of its enemies. There were other kinds of armored dinosaurs, but none quite so peculiar as the one just briefly sketched.

It is the general impression that extinct animals, especially the dinosaurs, have a corner on all that is unusual in size and grotesqueness of form. While in length they probably were the longest animals ever known, in bulk none of them exceeded the whales of the present day. In manner of appearance it must be borne in mind that many of the striking peculiarities of the dinosaurs are enhanced by their great size, for, were some of the living reptiles, especially the lizards, enlarged to the same proportions, they would be equally bizarre in appearance.

That in ancient days the regions where the dinosaurs lived enjoyed a warmer climate than that of to-day is abundantly indicated by the palms, cycads, figs and other tropical plants preserved as fossils with the animal remains. The dinosaurs were practically world-wide in their distribution, their remains having been found on all continents, but nowhere are they more abundant or in a better state of preservation than in that strip of country running north and south along the eastern flank of the Rocky Mountain range. Here is where the best preserved specimens have been found, but it may be of interest to know that these animals also lived along the Atlantic seaboard.

Another query that often arises is: How did the skeletons become entombed where they are found to-day? There are many ways in which this may happen, but a typical example will suffice. Animals dying in swamps may mire down into the water and muck and thus be immediately covered; or in the event of death having occurred along a stream the carcass, buoyed up by generated gases, might be carried down stream to be lodged in shallow water on a sand bar, where, as decomposition progressed, the bones of the skeleton would settle into the sand, there to be covered by shifting sand washed over them by the action of the current. This sand in many years following, accompanied by subsidence of the whole area, was covered deeper and deeper by other sediments, until finally many hundreds or even thousands of feet of overlying materials had accumulated. The great pressure brought about by the accumulated weight of the overlying strata consolidated the loose sand into hard sandstone, in which the fossils are commonly found. While all this has been going on the bones have also undergone a change, in that the organic matter of the bone has been replaced by mineral matter and the skeleton has become fully petrified. This has been brought about by the infiltration of water charged with mineral in solution, such as calcite, silica or iron, and as the organic matter is leached out the mineral is deposited in its place, until finally the fossil bone becomes as solid and heavy as rock itself.

The uncovering again of the fossils so deeply hidden by overlying sediments occurs only in favorable localities. It may be brought about by the erosion or carrying away of the superimposed strata, or by the more rapid cutting down through of a deep gorge of valley by streams and thus again uncovering the skeletons and making it possible for the collector of fossils to come into his own.

PERFUMES AND PROGRESS IN SCIENCE

By Dr. MARSTON T. BOGERT

PROFESSOR OF ORGANIC CHEMISTRY, COLUMBIA UNIVERSITY

I WONDER if my radio audience are familiar with the facts that the use of perfumes and perfumed unguents is as old as the human race; that some of the vases found in the tomb of the Pharaoh Tut-ankh-Amen were used to hold such materials; and that there used to be a law on the English statute books which made the use of perfumes subject to the same punishment as sorcery?

How has it come about that, of our five special senses of sight, hearing, taste, touch and smell, the cultivation of the last named has been not only neglected quite generally, but has also been scorned and more or less despised by most of the male sex as a frivolous and effeminate pursuit? Yet this sense was well developed and efficient in other animals long before the human animal, as we now know him, was evolved. So that from the dawn of his history man has distinguished between odors and derived enjoyment from those which appealed to him.

As an analytical instrument, the nose is far more delicate than the spectroscope, and the trace of an odor which it can clearly detect is unbelievably minute. No other sense is so marvelously acute as that of smell, so widely and extensively connected with other brain centers, or so potent in awakening our memories and our emotions. Kipling was physiologically and psychologically correct when he wrote that "Smells are surer than sounds or sights, to make the heartstrings crack." A breath of perfume brings instantly before our vision past scenes with all their pain or pleasure. Shrewd business men have already awakened to the powerful sales aid to be obtained from perfumes, and at last understand that an appeal to the nose is often more potent than one to the eye.

Why is it that the art of the perfumer is not taken so seriously as that of the musician, the painter or the sculptor? We teach our young people to distinguish musical sounds and color effects, harmony in music and in pictorial art, but the vast possibilities of artistic enjoyment provided in our wonderful olfactory endowment they are left to learn in the slow, unsatisfactory and casual school of practical experience, with the result that even our language lacks specific descriptive adjectives by which variations in odor can be accurately characterized in the same way that we can describe differences in color and in shade. There are masterpieces in perfumery, as in other arts, but those qualified to understand and appreciate them are few indeed.

Probably the reason why the sense of smell was extensively developed in animals sooner than the other special senses was that most wild animals depend more upon scent than they do upon sight to guard them against danger. In many animals this development far transcends what we find in man. The ability of dogs to follow unerringly a scent which can not be detected by the human nose is a familiar example.

Many insects are strongly odoriferous, the odors emitted being usually disagreeable, although "the males of many butterflies give off a pleasant fragrance similar to and rivaling in attractiveness that of the scented flowers." Insects also possess a remarkably well-developed sense of smell, and it seems quite certain that most human pests and parasites, like gnats, mosquitoes, bedbugs, etc., locate their prey mainly by odor. Some of the most striking investigations are those which have been carried out with ants, insects which exhibit also surpass-

ing powers of odor-association and odor-discrimination, enabling them not only to distinguish the smells characteristic of species, caste, sex and individual, as well as the adventitious odors of the nest or surroundings, but also even progressive odors due to the changing physiological condition of the individual with advancing age, a refinement which in the case of humans might often save us many complications and embarrassments.

This predilection of different forms of life for special odors has been used with considerable success to attract to their destruction not only animal pests, but insects as well. In this way, the geranium perfume has been used as a lure for the dreaded Japanese beetle, and an odorous constituent of the cotton plant for the boll weevil, the object being to induce these insects to collect in vast numbers, where they can be killed *en masse*.

The two major classes of perfume raw materials are the natural and the synthetic. Both are required for the production of fine modern toilet perfumes. They are the pigments with which the perfumer paints his picture.

The natural perfumes are either animal or vegetable. Of the former, but four are of any commercial importance, and these are the ambergris from the intestinal tract of the sperm whale; the musk from the preputial sac, or "pod," of the diminutive male musk deer, a graceful little creature, the sole source of genuine musk, now threatened with extinction, unless the recent brilliant efforts of the organic chemist in the preparation of new synthetic musks prove successful; the civet from the anal gland of the civet cat; and the castor, which consists of the dried preputial follicles and their secretion from both male and female beaver. The vast majority of natural perfumes, of course, come from the vegetable kingdom, where they occur as the volatile or essential oils, or as the gum resins and balsams. The flowers are not always the source of these odorous plant constituents. They may be in the wood, as in sandal and cedar; the bark, as in cassia and cinnamon; the leaves, as in patchouli, bay and thyme; the fruit, as lemon and bergamot; the seeds, as almond and caraway; or the roots, as orris and sassafras. From the appropriate part of the plant, the odorous constituents are obtained sometimes by direct pressure, sometimes by distillation with steam or extraction with suitable solvents; in other cases, the aroma exhaled by the flowers is absorbed by thin layers of fat or oil, from which material the perfume is subsequently extracted by alcohol. Do you know that it takes approximately two tons of roses to produce one pound of "attar" of roses?

The synthetics, on the other hand, are manufactured in man's laboratory instead of in that of the plant and, as in the case of drugs and dyestuffs, the organic chemist is rapidly outdistancing nature in this fascinating field, the sceptics in my audience to the contrary notwithstanding, and has already made available hosts of odorous products which nature does not provide. His intensive investigations necessary to achieve this result have meant striking progress in the science of chemistry. He has even discovered a synthetic geranium perfume which is so stable to heat and so cheap that it has been used successfully in a power-plant boiler, to generate steam. This geranium-scented boiler room has been in actual operation, although still in the experimental stage.

How impossible it is to foresee what may be the outcome of scientific research, or whither it may lead, is admirably illustrated by an investigation which began some forty years ago, the purpose of which was to discover the chemical to which the violet owed its delicious fragrance. The knowledge thus gained was used by the chemist to produce in his

laboratory some very fine violet perfumes, which have been used ever since in violet toilet preparations. Other chemists then investigated the perfume of orange blossoms and of some acacia flowers, and soon found out that the building blocks which nature had used in constructing these beautiful products were exactly the same as she used in making rubber, and differed only in their architectural arrangement.

It was these researches in the perfume field which have enabled us to learn so much about the chemical character of chlorophyll, of many other plant coloring matters, of some constituents of fish-liver oils of particular interest to the biologists and biochemists, and have led finally to a probable formula for vitamin A, that compound which has such a remarkable effect upon human growth and longevity. It certainly never entered the minds of these early workers in the perfume field that in unraveling the constitution of these perfumes they would discover the key which would unlock many other hitherto closed doors.

Who could have guessed that the delicious perfumes of the violet, of acacia flowers and of orange blossoms had anything whatsoever in common with the liver oils of the shark, flounder and mackerel, with the green (chlorophyll) and yellow (xanthophyll) coloring matters of leaves, of the red pigments of the tomato, of the red pepper, or of the Chinese lantern plant, the yellow or orange pigments of carrots, dandelions, sunflowers and yellow pansies and the brown coloring matter of some seaweeds; or that the molecular configuration responsible for orris and violet perfumes likewise formed an integral part of the molecule of the carrot pigment and of vitamin A?

Many human ailments are accompanied by the genesis of odors resulting from putrefactive or other destructive processes. These odors are specific chemical compounds, yet the medical profession seem strangely indifferent or sceptical concerning their value in the diagnosis of a disease, although it is not at all improbable that every pathogenic organism is characterized by the production of only certain definite odors. Those who have been so unfortunate as to have had surgical operations often acquire such a strong antipathy to the odor of the general anesthetic used as to render any subsequent operation doubly dreaded. Might not the incorporation of a suitable perfume in anesthetics and hypnotics diminish somewhat this feeling and enable the sufferer to fall asleep with the fragrance of some favorite aroma still in his nostrils? It might even influence pleasurably his dreams in that "twilight sleep" between consciousness and unconsciousness.

The perception of an odor is a physiological process, and further study of the connection between chemical constitution and odor will throw increasing light upon the dependence of other physiological effects as well as upon chemical constitution. This will show us how to cope more successfully with disease and to bring greater relief to human suffering. It is not by any manner of means inconceivable that the final solution of that master problem of chemistry, as to exactly what is the nature of those complex changes which determine the mysterious cycle we call life, may some day burst upon us as the direct outcome of the researches of the organic chemist in this "frivolous and effeminate" field of perfumes.

PHOTOGRAPHS OF THE WHALE SHARK, THE GREATEST OF THE SHARKS

By Dr. E. W. GUDGER

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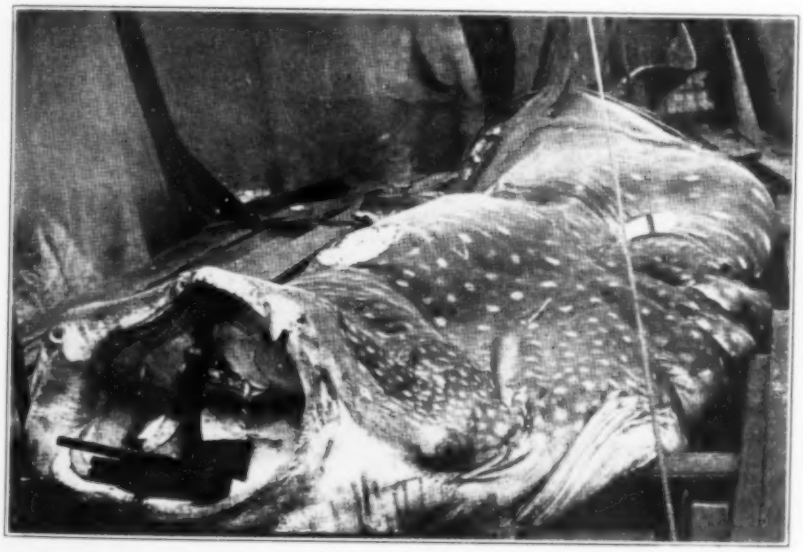
SHARKS are large marine fishes without any bony framework. Having only a cartilaginous backbone, very rudimentary cartilaginous pectoral and pelvic arches and no ribs, they are literally "loose-jointed." When brought out on land their bodies collapse and flatten down so that one can not get a true idea of their form, shape and proportions. This is particularly true of the whale shark, the largest, bulkiest and probably the most collapsible of all the sharks.

However, despite these things, photographs of the whale shark are especially desirable, since they will at any rate give some idea of the size and shape of the body, of the sizes and positions of the fins, and of the size and position of the vertical yellow bars and of the rows of large yellow spots between these. Having in my possession copies of all the photographs known to have been taken of the fish itself (excluding mounted skins and models) I have thought it well to bring these together for the instruction and use of those interested. Reproductions of all drawings, models and mounted skins may be found in a recent article[1] by me.

[1] E. W. Gudger, "The Fourth Florida Whale Shark, *Rhincodon typus*, and the American Museum Model Based on It," *Bulletin American Museum of Natural History*, 65: 613–637, 10 pls., 4 text-figs., 1931.



—*After Gudger, 1915*

FIG. 1. THE SECOND FLORIDA WHALE SHARK—1912

DRAWN OUT OF WATER ON THE MARINE RAILWAY AT MIAMI.

—*After Gudger and Hoffmann, 1927*

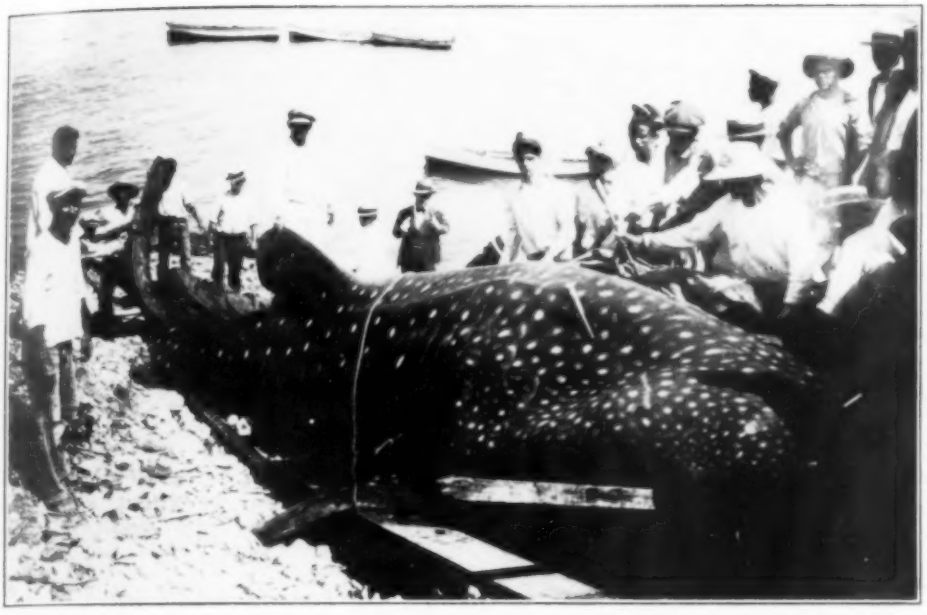
FIG. 2. NINE MEN ON A WHALE SHARK'S BACK

THE SPECIMEN TAKEN AT JAIMANITAS, CUBA, 1927.

—*After Gudger and Hoffmann, 1927*

FIG 3. THE CAVERNOUS MOUTH OF THE JAIMANITAS SHARK

HELD OPEN BY THE HARPOON WITH WHICH IT WAS SECURED. NOTE HOW FLATTENED OUT THE FISH IS.



—*After Gudger and Hoffmann, 1930*

FIG. 4. THE WHALE SHARK ON THE SHORE AT COJIMAR BAY, CUBA
THIS SHOWS WELL THE REMARKABLE SPOTTING OF THIS GREAT FISH.

It seems well in this short note to restrict the figures to reproductions of photographs, showing the shark out of water and hence portraying approximately the whole fish. First, published figures will be given, and then several which have never before been reproduced.

The first of the former is taken from my paper on the "Natural History of the Whale Shark,"[2] published in 1915. This (Fig. 1 herein) is of the 38-foot specimen captured near Knight's Key, Florida, in May, 1912. It is here shown drawn up on the marine railway at Miami. As will be seen, it has collapsed and, since the "cradle" on which it rests had no flooring of planks, it is badly out of shape. However, one gets an idea of its enormous size, of its remarkable coloration, of the cavernous mouth with the tooth-bands showing indistinctly, of the small eye and of the large gill-slits.

In November, 1927, a 31-foot whale shark was captured at Jaimanitas, a fishing village about five miles west of the mouth of Havana Harbor. In an article by Dr. W. H. Hoffmann, of Havana, and myself,[3] we reproduced three photographs of this great fish on the beach. Fig. 2 herein shows this great fish drawn partly on shore with nine men perched on its broad back. The collapsing when brought ashore is here shown plainly. Fig. 3 herein (Fig. 3 of our article) gives a good idea of the great shark. Note the prodigious mouth (held open by the harpoon with which it was secured), the great spread of the pectoral fins, the high-standing dorsal fin, the great length of the fish, and the upper half of the tail, which is nearly as high as a man is tall.

[2] *Zoologica: Sci. Contribs. New York Zool. Soc.*, Vol. 1, No. 19, p. 354, fig. 122.

[3] *American Museum Novitates*, 1928, no. 318, 3 figs.

Some two and a half years after the capture of the Havana whale shark just figured, another was captured at Cojimar Bay, east of Havana Harbor, in March, 1930. Dr. Hoffmann and I published a note on its occurrence (without any illustration) in *Science* for June 20 of that year, and in the January issue of SCIENTIFIC MONTHLY for 1931 we published the beautiful photograph reproduced herein as Fig. 4. This well portrays the great size and remarkable spotting of this 34-foot specimen. The two harpoons with which it was struck are shown, as also the wire rope with which it was finally secured. The view of the head is marred by the shadow cast by one of the bystanders.

In this connection it may be said that Dr. Hoffmann and I have reports, which we think credible, that other whale sharks have been seen by fishermen in the Havana region. It does not seem too much to expect further accounts with photographs of this great shark in this immediate vicinity.

These figures comprise all the published photographs showing the whole fish. Now follow four previously unpublished ones.

The first of these is a re-photograph of an old dilapidated picture made of a whale shark taken at Bacolod, Philippine Islands, in 1910. This (Fig. 5 herein) was kindly sent me by Dr. A. W. Herre of Stanford University. It was obtained while he was head of the ichthyological work of the Philippine Bureau of Science. No data are available as to size, but it was apparently between 20 and 25 feet long. It may be added that the whale shark is well known in the Philippine Islands—there are several accounts in the literature and many as yet unpublished.

The whale shark has been reported a number of times in the seas around Java, but unfortunately only one photo-

—Photograph by courtesy of Dr. A. W. Herre

FIG. 5. WHALE SHARK TAKEN AT BACOLOD, PHILIPPINE ISLANDS, IN 1910

NOTE THE KEELS AND CHAMFERINGS RUNNING FROM THE SHOULDER REGION BACK TOWARDS THE TAIL AND ALSO THE BOY IN THE FISH'S MOUTH.

—*Photograph by courtesy of Dr. P. N. Von Kampen*

FIG. 6. A WHALE SHARK SUSPENDED ABOVE THE HARBOR OF SOERABAYA, JAVA

NOTE THE ENORMOUS GILL-SLITS, THE HINDMOST BEING THE SMALLEST.

graph has, so far as I know, ever been made. This is reproduced as my next figure, No. 6. It is a photograph of a whale shark suspended above the water of the harbor of Soerabaya, Java. This was kindly loaned me by Dr. P. N. Van Kampen of Leyden, Holland. He purchased the photograph in Java and knows nothing of the specimen, beyond the fact that it was said to have been taken in the Straits of Madeira between Java and the island of Madeira. The fish is apparently about 18 or 20 feet long. It is of course very much distorted by the way it is suspended, but at least it gives a fine idea of the great size of the gill-slits. The shape of the pectoral fin is also well shown.

Next comes a photograph, which has recently been sent to me by Mr. Wallace

—*Photograph by courtesy of Mr. Wallace Adams*

FIG. 7. PHOTOGRAPH OF A SECOND PHILIPPINE RHINEODON

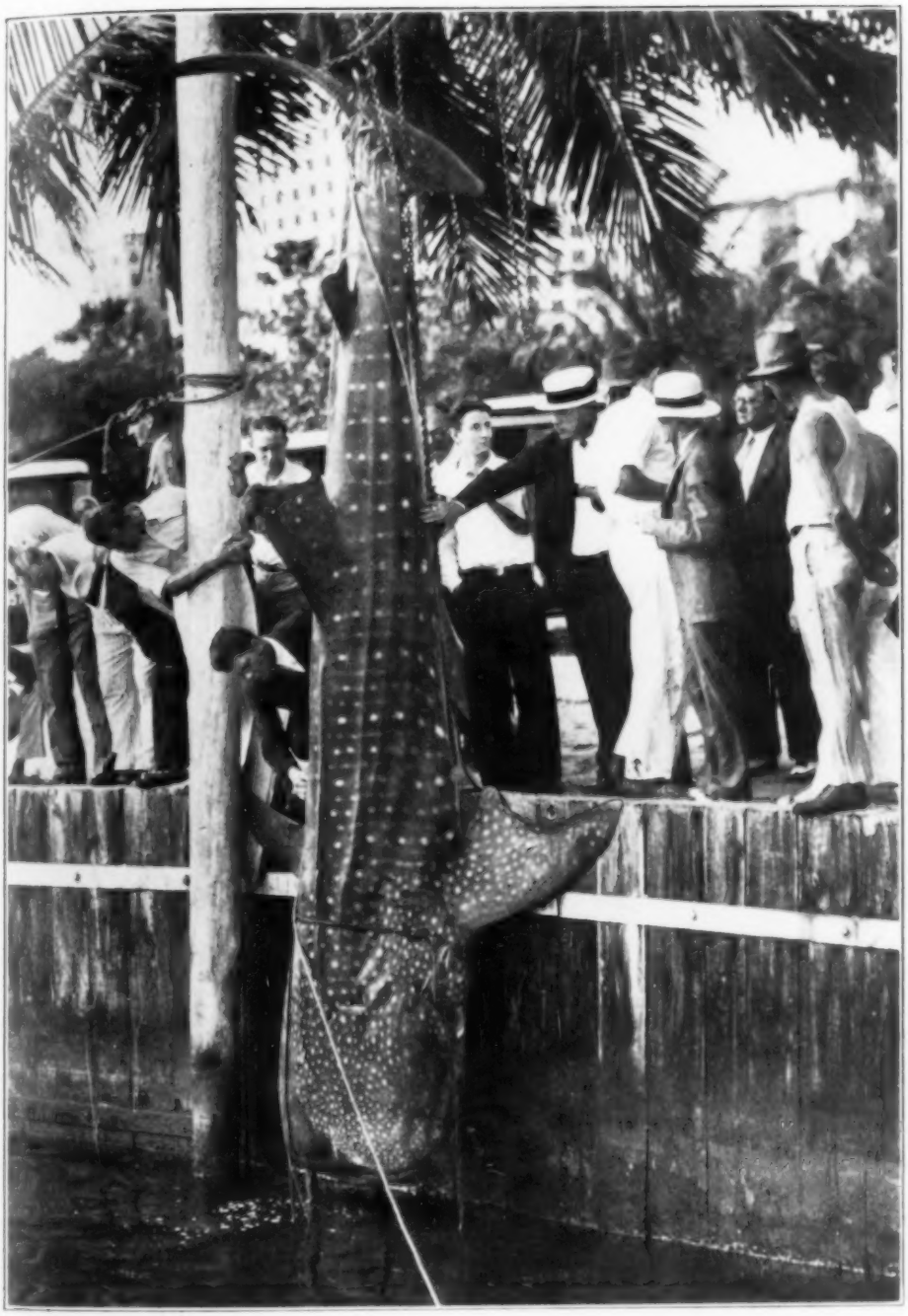
A 21-FOOT SPECIMEN TAKEN IN A FISH TRAP AT BARRIO APLAYA, BAUAN, BATANGAS, LUZON, MARCH, 1932.

Adams, chief of the Division of Fisheries, Philippine Bureau of Science, Manila. The specimen shown therein was caught in a fish trap at Barrio Aplaya, Bauan, Batangas, Luzon Island. It entered the trap on March 4, 1932, and died during the night of the 7th. It was measured by the local doctor, who found that it was 21 feet long (5.37 m) and had a girth of 13.5 feet (3.44 m). The shark had unfortunately been towed out to sea and sunk when Mr. Wallace's photographer and preparator reached the spot. Fortunately, however, a local photographer had taken a picture of it and a copy was procured by Mr. Wallace's aides. Fig. 7 is made from this. It shows the fish in lateral view as it was drawn out on the beach. The reader's attention is called to the small eye, the flat head, the long gill-slits, the spots and the longitudinal ridges.

In this connection, and in view of the fact that two photographs of the whale shark in the Philippines are reproduced herein, it will be of interest to state that this great fish seems probably to be more abundant here than anywhere else in the world. This conclusion is based on 12 authentic records and about as many doubtful ones collected by Mr. Adams. He will shortly bring these data together and publish them. Perhaps it is not too much to hope that he may presently get better photographs than those from the Philippines reproduced herein.

Best of all the photographs are those of the 18-foot specimen captured off Miami, Florida, on January 18, 1932. I have put this specimen on record (*Science*, April 15, 1932) and now have pleasure in doing the same thing for the best of these photographs. Fig. 9 shows the anterior half of the fish resting on the ground with the tail partly suspended in the air. This shows the huge mouth and gullet in close view. If only a mirror had been used to light the interior of this cavern, it would have added greatly to the scientific value of the photograph.

In the magnificent photograph reproduced as Fig. 8 the fish is suspended clear of the water. This is a quartering lateral view which portrays nearly



—Photograph by courtesy of Miami Herald Studio

FIG. 8. THE MIAMI (1932) WHALE SHARK SUSPENDED BY THE TAIL

NOTE THE GENERAL FORM, THE CHAMFERINGS, AND ESPECIALLY THE BARS AND SPOTS.

—*Photograph by courtesy of Mr. John Mills and Mr. Albert Pflueger*

FIG. 9. HEAD-ON VIEW OF THE MIAMI WHALE SHARK, 1932

THE FISH, PARTLY LYING ON THE GROUND, HAS FLATTENED OUT VERY MUCH.

everything one wishes to see in the fish —the general shape, the fins, the lateral keels and chamferings, and the remarkable color-pattern. One wishes that the tail could have been held flat in the vertical-longitudinal plane of the body so that the conformation of the lobes would have been shown. Another photograph looking squarely at the median plane of the body would have shown the shape of the snout, head and shoulder-parts—all great desiderata.

I have two photographs taken at practically this angle, but the better for reproduction is that (Fig. 8) sent by the studio of the *Miami Herald*, and my hearty thanks for it are hereby expressed.

THE PROGRESS OF SCIENCE

APPLIED SCIENCE AND INDUSTRY AT "A CENTURY OF PROGRESS" EXPOSITION

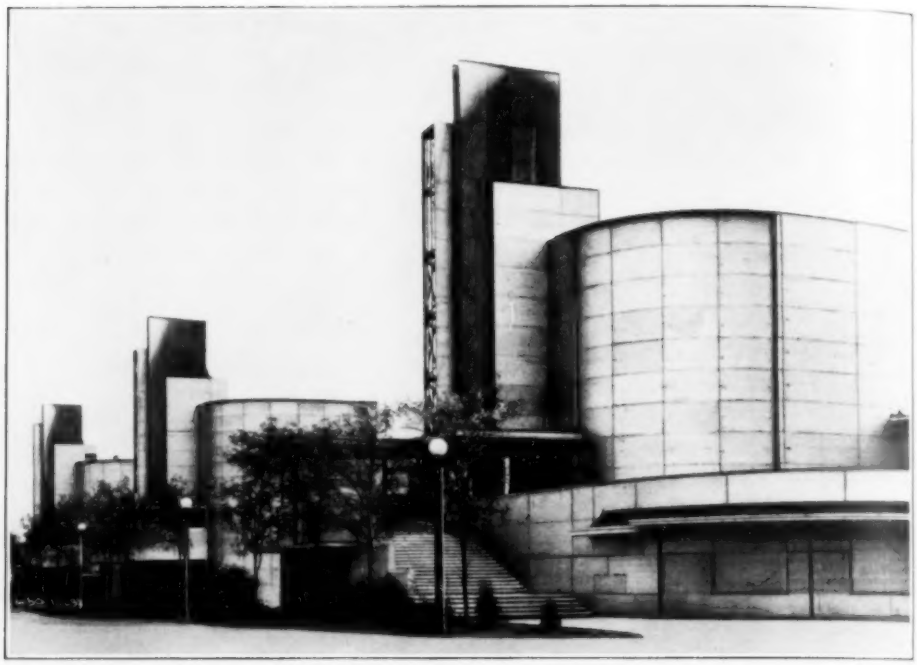
THE name, "A Century of Progress," was selected as descriptive of the theme of the exposition, which is to exhibit and portray to the peoples of the world the nature and significance of scientific discoveries and inventions based thereon, and the changes which the applications of scientific discoveries and inventions have wrought in industry and in living conditions during the past century.

In order that the exposition might have an appropriate scenario for its theme, the National Research Council was requested to appoint a Science Advisory Committee to prepare reports not only as to what should be portrayed by the basic science exhibits but also what should be included in the exhibits to show the application of scientific discoveries in industry. These reports have served as a basic guide in seeking the participation of industry.

It is the function of the Applied Science and Industry Division to secure the participation of industry in a manner in keeping with the theme of the exposition. In general, men with experience in the various branches of industry have been placed in charge of appropriate sections and have developed their work with the advice and cooperation of the members of the Basic Science Division staff. This cooperation has been mutually helpful. The first approaches to nearly all industries were made with a view to securing group participation from the industry. This plan succeeded with several industries. With many industries, however, either because the members of the industry were highly competitive among themselves, or because the financial condition of a large proportion of the membership was poor, the group plan had to be dropped and the plan to secure the same type of exhibits from the leading corporations in the industry substituted. The officials of many large corporations quickly grasped the idea that an exhibit in keeping with the theme of the exposition would be far better prestige advertising for them than exhibits of their products.

THE AGRICULTURAL BUILDING OF THE AGRICULTURAL GROUP

IN WHICH A NEW KIND OF FOOD AND FARM IMPLEMENT SHOW WILL ATTRACT BOTH FARMER AND CITY DWELLER.



PAVILIONS OF THE GENERAL EXHIBITS GROUP

WHICH WILL CONTAIN THE EXHIBITS OF THE MINERAL INDUSTRIES AND INDUSTRIAL ENGINEERING RELATED THERETO, AND THE HISTORICAL AND PROCESS EXHIBITS OF THE GRAPHIC AND INDUSTRIAL ART INDUSTRIES.

The Applied Science and Industry Exhibits will, in general, portray the application of scientific discoveries in the industry, features of historic interest, processes of manufacture, final products and the effects of the development of the industry on living conditions in cities and on farms. The work of engineers is shown as an integral part of the industrial exhibits instead of something segregated and set apart by itself. The exhibits are non-competitive and no prizes are awarded. Certificates of participation will be presented to exhibitors. From the nature of the exhibits, applicants who wish to present single articles for exhibition are barred unless they can have the articles incorporated as a part of a large exhibit where they fit into the stories being presented and have some meaning.

The Applied Science and Industry Exhibits are arranged in six grand groups, as follows:

(1) The Travel and Transport Group includes exhibits of transportation by rail, highway, waterway and in the air, together with exhibits by the associated industries such as the manufacturers of railway equipment and supply, automotive equipment and supply, etc. Travel features, both foreign and domestic, are stressed.

(2) The Electrical Group includes exhibits of the manufacture of electrical machines; the generation, distribution and utilization of electrical power, the applications of electricity in communication, and the utilization of electricity in radio transmission.

(3) The Agricultural Group includes exhibits of food products, farm machinery and equipment, dairy products and poultry.

(4) The Medical and Chemical Group includes exhibits from manufacturers of articles which serve the medical professions and from the closely associated manufacturers of chemicals. These exhibits will be shown in the Hall of Science in proximity to the scientific exhibits in medicine and under the same roof with the other basic science exhibits.

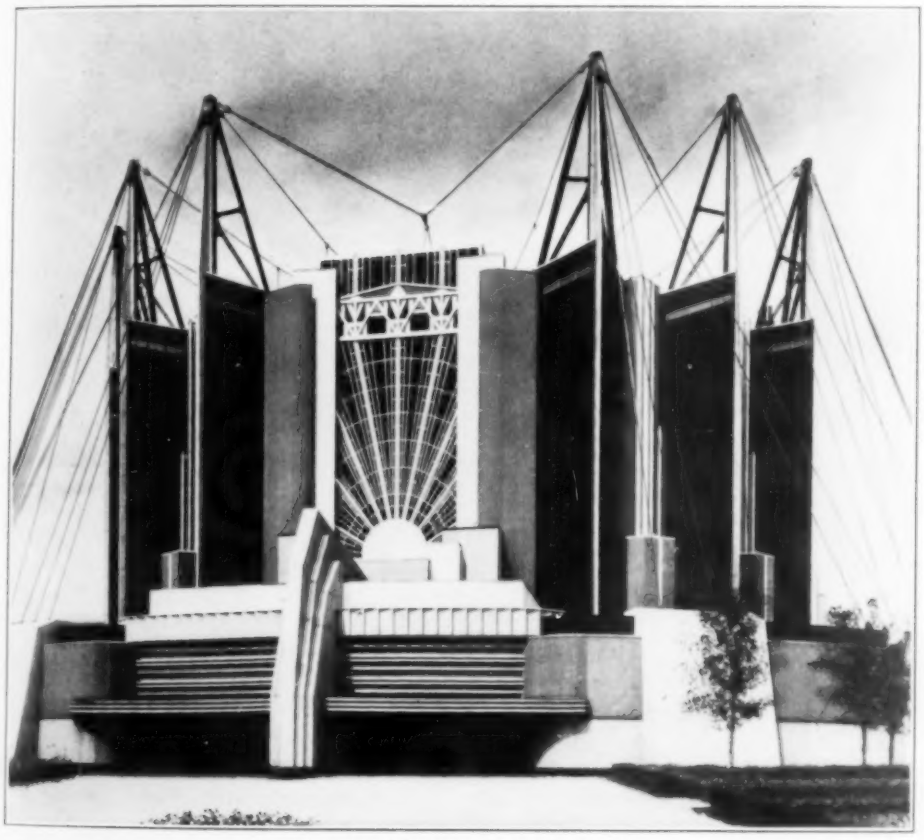
(5) The General Exhibits Group includes the exhibits of the mineral industries and industrial engineering related thereto and the his-

torical and process exhibits of the graphic and industrial art industries.

(6) While the above five grand groups provide a place for the exhibits of any industry, the need was felt for another group where the applications of any industry in the home and municipality could be more effectively portrayed in conjunction with the products of other industries. So a Home and Industrial Arts Group was created. Here new materials and methods of construction, the genius of interior decorators and home planners, the work of municipal and sanitary engineers and the products of those manufacturers who featured home furnishings and equipment will be on view.

Four months prior to the opening date of the exposition the work of securing the participation of industry necessary to present the applied science and industry exhibits is 80 per cent. completed. It is estimated that the expenditures for exhibit space and special buildings by exhibitors will reach a total of approximately $6,000,000 and that additional expenditures for the preparation, installation and maintenance of exhibits will total from $8,000,000 to $10,000,000. Industry will present to men of science and to all visitors a marvelous display of what research engineers and the officials of industry have done in applying the discoveries of men of science to develop industries and improve living conditions.

J. Franklin Bell,
Chief, Applied Science and Industry Division



THE TRANSPORTATION DOME.

In this unique structure, erected on the principles of a suspension bridge, will be housed exhibits portraying the development of transportation during the past century. This dome, 310 feet across the base and with an unobstructed interior height of 124 feet, is the central feature of the Travel and Transport Group.

DR. HENRY FAIRFIELD OSBORN, RETIRING PRESIDENT OF THE AMERICAN MUSEUM OF NATURAL HISTORY[1]

"QUAERIS monumentum, circumspice," said Augustus Caesar, as the stately columns of the Eternal City rose beneath his approving eye. "L'état, c'est moi," quietly observed the Grand Monarch as he signed the order to make the dirt fly for the foundations of the magnificent palace of Versailles. History is silent as to the words of Cheops when he completed the greatest archeological exhibit of antiquity; but fortunately there will be no lack of publicity on the occasion of the completion of the new wings of the American Museum of Natural History. Even from the trough of the depression we may raise thanks that this country is still producing monument builders of the caliber of J. P. Morgan, John D. Rockefeller and Henry Fairfield Osborn.

There was once a stern ruler of the metropolis who denounced the Interests, defied the Plutocrats, scorned Aristocrats and booed at Experts; but Professor Osborn, an almost officially accredited representative of these proscribed classes, went and spoke soothingly to him of science, of education, of the millions of future citizens that the museum feeds with spiritual enlightenment and love of the beautiful, *et cetera, et cetera.* To his infinite credit Mayor Hylan (for it was he) became Professor Osborn's devoted backer and supporter, working valiantly with him to secure for the museum the buildings and maintenance that were urgently necessary for its civic functioning.

So it has been through the fifty-odd years of Professor Osborn's career as a builder—at Princeton, at Columbia, in the New York Zoological Park, at the American Museum and as president of the Roosevelt Memorial Commission. Temporary opposition has only spurred him on to greater effort and one triumph has but opened the way to the next.

But let it be distinctly understood, President Osborn differs widely from Louis XIV and from Cheops precisely in that he does not aspire to run a one-man show or build a monument with his name alone inscribed thereon in bronze or granite. He has always been a leader, yes, but a leader of men whose names he delights to honor, brave companions in arms who have shared his triumphs with him and in whose achievements the old general takes the most generous satisfaction. Such a blue-eyed field commander, after his own heart, is Roy Chapman Andrews, who carried the flag of the American Museum into the deserts of central Asia and there opened up the astonishing new world of Ancient Mongolia. But what inspired Andrews to go there were Professor Osborn's professional prophecies, first uttered in 1899 and 1900, that central Asia would some day be found to be the home of many families of mammals, families which during the long ages of the Age of Mammals sent out colonists to western Europe and western North America and left their fossil bones to fill the great halls of the American Museum of Natural History. And what enabled Andrews to raise the funds for this scientific invasion of the Gobi Desert were not only his own brilliance and daring but the powerful backing of his beloved chief.

Walter Granger and Barnum Brown are equally trusted lieutenants of Professor Osborn—tall, quiet men, who move deliberately over great fields and call up long dead hosts from ancient battle-grounds. And great is Professor Osborn's joy when among the younger

[1] In view of the recent retirement of Dr. Henry Fairfield Osborn as president of the board of trustees of the American Museum of Natural History this note of appreciation of his services to the Museum and of his personal characteristics has been prepared at the request of the editor.

Pach Brothers

DR. HENRY FAIRFIELD OSBORN

RETIRING PRESIDENT OF THE AMERICAN MUSEUM OF NATURAL HISTORY.

men he discovers one like Dr. George Gaylord Simpson, to whom he can confidently entrust the huge paleontological investigations of the next generation.

The same generous, friendly spirit has animated Professor Osborn's personal and family life. His wife, Lucretia Perry Osborn, was also his complete partner, who shared with him every civic and scientific labor and every triumph. She was truly the "Spirit of Castle Rock," their residence at Garrison, New York, and no guest of theirs will ever forget a visit with them. And now his sons and daughters and grandchildren rejoice that at seventy-six he labors on with undiminished zest.

Fortunately it was not because of failing power that Professor Osborn resigned the presidency of the board of trustees of the American Museum of Natural History, but because he had discovered among his younger associates a man whom he recognized as able and willing to carry the great burden of that office. It was no mere gesture then when Professor Osborn, on the occasion of the inauguration of Mr. H. Trubee Davison as his successor, spoke of the world-wide explorations of the museum and then suddenly picked up a large terrestrial globe and placed it in Mr. Davison's momentarily hesitant arms. And it is no wonder that the latter spoke feelingly of his realization of the magnitude of his task. But all those who know well both Professor Osborn and Mr. Davison have the greatest confidence in the result. And both the honorary president, the new president and the board of trustees will doubtless continue to entrust the entire internal management of their ship to Director George H. Sherwood, who has long been responsible for the smooth working of its vast and complicated machinery.

Thus Professor Osborn will now have more leisure to devote to the completion of the series of monographs for which he has long been justly famous among the paleontologists of the world. The monograph on "The Evolution of the Titanotheres," published in 1929 as the result of twenty years' work, numbered 953 pages and included 797 text figures and 236 plates. The monograph on "The Proboscidea," now nearing completion, will make even the Titanothere monograph look small. Meanwhile among the almost nine hundred numbers of his scientific writings, the "Age of Mammals," "Men of the Old Stone Age" and "The Origin and Evolution of Life" continue to hold a deservedly high place in the estimation of his admiring public.

JOHN JOSEPH CARTY

Dr. John J. Carty, pioneer in the development of the telephone art since its early days, died on December 27 at the Johns Hopkins Hospital. Born in Cambridge, Massachusetts, in 1861, Carty completed a course in the Cambridge Latin School and in 1879 began his telephone career, three years after the telephone's invention, when he entered the employ of the Telephone Dispatch Company of Boston. His natural ability and his fondness for scientific investigation led to a long series of valuable contributions to the advancement of the telephone art. Concerning them Dr. F. B. Jewett writes in *Science:*

"His invention of the 'common battery' for supplying operating current from a single central office battery to any number of intereonnected telephones made practical the commercial development of telephony in metropolitan areas.

"His development of the high resistance bridging signal bell for subscribers substations to replace the theretofore universally employed low resistance series bell, tore the hampering shackles from a wide-spread extension in the use

JOHN JOSEPH CARTY
1861–1932

of the telephone. Every telephone set now in use employs such a signal.

"Equally revolutionary and of a more distinctly scientific character was his discovery that the principal cause of cross interference between telephone circuits was electrostatic and not electromagnetic unbalance. This discovery and the rules which General Carty worked out for the proper construction of adjacent telephone circuits are now universally employed."

Many important engineering problems confronted General Carty during the years while he served as chief engineer of the American Telephone and Telegraph Company. Perhaps the most notable of these was the completion in 1915 of the transcontinental telephone line which made possible the first transmission of speech between the Atlantic and Pacific coasts and thus achieved a dream which Carty himself had long cherished—nation-wide telephone service. Shortly after this achievement was announced, engineers working under Carty's direction accomplished the first successful transmission of speech by radiotelephone from New York to San Francisco, to the Hawaiian Islands and to Paris—the pioneer efforts in the development of a system of radiotelephone facilities which now are practically world-wide in their reach.

In 1919 General Carty was elected vice-president of the American Telephone and Telegraph Company in charge of the department of development and research. In 1925 he was also made chairman of the board of directors of the Bell Telephone Laboratories. He retired from active participation in telephone work in 1930.

Among the scientific and engineering awards which have been granted to General Carty are: The Edward Longstreth Medal, the Franklin Medal for eminent service in science, the Edison Medal for "work in the science and art of telephone engineering," the John Fritz Gold Medal "for pioneer achievement in telephone engineering and in the development of scientific research in the telephone art." The National Academy of Sciences established the John J. Carty Medal in his honor, and made the first award to him, the actual presentation of which was to have taken place at its annual meeting in April.

In his tribute Dr. Jewett writes:

"General Carty had an insatiable desire to enlarge his own fund of information and understanding. All who came in contact with him, from the most wise to the most frivolous and shallow, were subjects for his inquiry. He gave much and willingly of his store of knowledge and wisdom but in return, and frequently in ways unknown to his vis-à-vis, he exacted payment in full measure. At times this payment was in kind; more frequently than not it was in values quite foreign to the main subject-matter of the conversation. At the termination of the contact General Carty had invariably something new added to his already great store of knowledge—a bit of social history or custom, a hitherto unknown item of science, a peculiar slant of political thinking, or any other of the thousand and one things which involve the working of human emotions or the human mind.

"His relentless search into the way human beings react and into the motives which guide their thought and action, and whose results he continually marshaled and remarshaled under the guidance of his incisively analytical mind, became a main source of his extraordinary capacity for being always at home in any company. Few men possess the capacity which General Carty had for meeting on a plane of complete understanding men and women of every social and intellectual gradation. It was a capacity which enabled him in every situation to give and receive knowledge and to influence the outcome of events in ways and in a manner which were frequently uncanny."

QUANTUM MECHANICS AND CHEMISTRY

For nine successive years the American Association for the Advancement of Science has awarded a prize of one thousand dollars for a notable contribution presented at its annual meeting. The prize for 1932 was awarded at the Atlantic City meeting of the association to Dr. Henry Eyring, of Princeton University, for the paper presenting his theoretical calculations of rates of chemical reactions.

Life processes, in fact practically all changes, are a result of chemical reactions so that any progress toward a better understanding of chemical processes is of very general interest. It is a familiar fact that most reactions approximately double their rate for a temperature rise of ten degrees. Practical application of this fact is made, for example, in the preservation of foods by refrigeration. A chemical reaction consists in an atom exchanging one of its partners for a new one. An atom which has the normal complement of companion atoms allows additional atoms to approach it only with the utmost difficulty. In fact, this is only possible in the case of rare cataclysmically violent collisions. At any attainable temperature these very violent collisions are rare, but the number increases with a rise in temperature. The energy with which two molecules must collide in order to change partners is called the activation energy and the critical configuration is called the activated state.

The method of calculating how frequently collisions of a specified violence occur is well known, so that if we can predict how energetic a collision is required for a given reaction we can calculate the rate of the reaction. It is just this problem of calculating activation energies which Dr. Eyring has attacked, using the quantum mechanics.

Starting with two molecules, it may be possible to form the same new molecules by a great variety of intermediate steps. Thus one of the molecules may first break up into atoms, after which one of the atoms may react with the second molecule or the two molecules may react in a single process. The process most economical of energy will be the one which actually occurs so that theoretical calculations suffice to indicate the actual process. Calculation and experiment agree in all the cases investigated. Another interesting result of the calculations is that hydrogen and fluorine do not react at ordinary temperatures in agreement with the newest experiments but contrary to the much quoted older ones. The method has given a satisfactory picture of certain reactions occurring on surfaces and shows why in general the lighter of two isotopes should be slightly more reactive. This latter effect should be useful in the separation of isotopes. The calculations also exclude certain proposed mechanisms in the photochemical reaction of hydrogen with chlorine, in which case again it agrees with the most recent experimental results. Dr. Eyring's newest calculations serve to explain why both hydrogen and bromine add to the two end carbon atoms of butadiene. Butadiene is the simplest example of what is known to chemists as a conjugate double bond system. The method thus appears capable of dealing with rather complicated molecules. Indeed the difficulty in applying the method depends on the complexity of the chemical change which occurs rather than on the complexity of the molecules reacting, since atoms remote from those which are reacting play an insignificant rôle.

Dr. Eyring states that "there is thus accumulating an empirical foundation for the method more compelling than that which may at present be adduced from strictly theoretical considerations. The qualitative correctness in all cases of the calculations indicate that it is a surprisingly powerful tool with which to attack the almost endless variety of problems of chemical mechanism."

MEASUREMENT OF THE COUNTERGLOW

In the dark night sky, when one is far away from city glare, it is sometimes possible to detect a faint patch of light, in a position directly opposite that of the sun. This is called the "gegenschein," or counterglow, and is due to the reflection of sunlight from a swarm of minute particles far out in space. Though even the ancient astronomers could probably have seen it if they had looked, its discovery was actually not recorded until 1885 by a German astronomer named Theodor Brorsen. Now the "electric eye" again rivals its human counterpart, not only in permitting scientists to detect the gegenschein, but also in measuring its brightness. Dr. C. T. Elvey, of Yerkes Observatory, has just announced, according to Science Service, the results of his study of this faint object with a photoelectric cell attached to the Yerkes 40-inch refractor telescope.

Dr. Elvey's method was to point the telescope to a part of the sky nearly free from stars, and just to the north or south of where the gegenschein should be. Even the night sky is not entirely dark, so a small amount of light fell on the photoelectric cell, producing a minute electric current, which was detected on an electrometer. Then the instrument was moved toward the gegenschein, and another reading taken. This process was continued, readings at regular intervals being made along a north and south line, until the gegenschein was well passed. When these data were plotted, the curve showed a hump, which was due to the extra light from the glow itself. Then Dr. Elvey took a series of readings along parallel north and south lines in the sky, to one side, through and to the other side of the glow. This gave the brightness of a series of points in the sky, and when these were drawn in their proper positions, and those of equal brightness connected, the lines showed a roughly elliptical area outlining the gegenschein.

He has found that the total brightness of the object is about that of a star of the minus .28 magnitude, brighter than any seen from these latitudes except Sirius, the dog star. But instead of being concentrated in a point, like the star, this amount of light is spread over an area as large as many an entire constellation. At the center, where brightest, the intensity is equal to that of a star of 6.2 magnitude, just below naked eye visibility under any but the best conditions.

Dr. Elvey's measures show that the gegenschein is egg-shaped, and is from 22 to 35 degrees in length and 21 to 26 degrees in height. A degree in the sky is about twice the diameter of the moon or sun. However, on one night when the observations were being made, reports Dr. Elvey, the gegenschein appeared only about half as large as indicated by the measurements.

The particles which cause the gegenschein are distributed around the sun in the shape of a lens, and extend out beyond the earth's orbit. They also cause the zodiacal light, which is much more easily seen. The phenomenon appears after sunset or before sunrise, as a faint, tapering beam of light, extending along the sun's path for perhaps 90 degrees from the sun.

The gegenschein can best be seen at midnight, for then it is highest in the sky. At certain times of the year it is blotted out by the Milky Way. It is well away from the Milky Way in October and November, the best months for observing it.